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Missouri Bureau of Geology and Mines
ERNEST ROBERTSON BUCKLEY, Ph. D.
Director and State Geologist.

C. W. Hall

# BIENNIAL REPORT

OF THE

1901-02

# STATE GEOLOGIST

TRANSMITTED BY THE

## BOARD OF MANAGERS

OF THE

## BUREAU OF GEOLOGY AND MINES

TO THE

## 42nd GENERAL ASSEMBLY

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS
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Missouri Bureau of Geology and Mines

ERNEST ROBERTSON BUCKLEY, Ph, D.

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2,000 Copies ordered printed by Senate.

C. ROACH, Secretary.

3,000 Copies ordered printed by House.

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# PREFATORY LETTER.

Bureau of Geology and Mines,
Rolla, Mo., Dec. 1, 1902.

To the President, Governor A. M. Dockery, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines from September 12th, 1901, to the present date. An idea of the diversified character of the work of this department cannot be adequately conveyed in a report of this nature, but it is hoped that enough has been said to emphasize the importance of this department to the people of the State.

I wish in this place to express to the members of the Board my appreciation of the deep interest which they have manifested in the work of the Bureau. Both individually and collectively the members have contributed largely to whatever success may have been attained by the present administration. No sacrifice of time or attention has been too great to further the interests of this department.

Your obedient sir,

E. R. BUCKLEY.

# INTRODUCTION.

At the last session of the Legislature, sections 7502 and 7502a of the law creating the Bureau of Geology and Mines were amended so as to read as follows:

"Section 7502. The board of managers are authorized, as soon as they are organized, to appoint one state geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy, and whose headquarters shall be located at the state school of mines at Rolla, who shall be the director of the survey, and said state geologist may appoint such assistants and subordinate assistants and laborers as may be deemed necessary in order to make a thorough scientific, geological, and mineralogical survey of the state.

Section 7502a. The board of managers of the bureau of geology and mines are hereby authorized and directed to transfer all instruments, books, charts, cabinet collections and other property of the state of Missouri now under the control of said board to the state school of mines at Rolla and establish the headquarters of the geological survey at said state school of mines."

In accordance with the above instructions, the headquarters of the Bureau have been removed from Jefferson City to Rolla and are now locatd in a building belonging to the School of Mines and known as the "Club House." All instruments, books, charts, cabinet collections and other property of the Bureau have also been transferred to Rolla, as directed.

At the time of taking charge of the Bureau, September 12, 1901, the furniture, fixtures, library and cabinet collections were packed as they had been shipped from Jefferson City. It, therefore, became my duty not only to plan the work of the survey, but at the same time to oversee, personally, the unpacking of the furniture, library and cabinet collections; the cleaning, papering and repairing of the building; the erection of the cabinets; and many other details incident upon the removal of the Bureau to Rolla. This work has consumed much of the spare time of

myself and assistants, although a greater part of the work of unpacking and arranging of the mineralogical and paleontological specimens was done during the winter evenings.

The Bureau is now in excellent working condition and, if sustained, it should become an indispensable factor in the development of the resources of the state.

### REPORTS FOR DISTRIBUTION.

On the 12th of September, 1901, there were the following volumes of the reports of this Bureau remaining for distribution:

| | |
|---|---|
| Preliminary Report on Structural and Economic Geology.—Vol. XIII, 1900, by John A. Gallaher | 3632 |
| New Year's Announcement, Jan. 1, 1901, by John A. Gallaher | 463 |
| Biennial Report of the State Geologist to the 41st General Assembly, by Leo Gallaher | 493 |
| Higginsville Sheets (without maps), by Arthur Winslow | 275 |
| Areal Geology, Vol. XII, Part II, by C. F. Marbut and G. C. Broadhead | 242 |
| Biennial Report of the State Geologist to the 39th General Assembly, by Chas. R. Keyes | 210 |
| Coal Deposits, Vol. I, by Arthur Winslow | 189 |
| Lower Carboniferous Crinoids, Bul. No. 4, by S. A. Miller | 9 |
| Boone County and Ozark Uplift, G. C. Broadhead | 8 |

Distribution.—The above reports have been distributed upon application, provided the request were accompanied with stamps to cover postage. Volume I has been sent out upon receipt of 15 cents in stamps, and Volume XIII upon receipt of 25 cents in stamps. The other reports require from 2 to 22 cents each for postage. Volume I, Bulletin No. 4 and the bulletin on "Boone county and the Ozark Uplift," have been exhausted and are no longer obtainable from this office.

Since September 12, 1901, there have been distributed 45 copies of Volume I and 244 copies of Volume XIII.

### SPECIMENS IN THE MUSEUM.

Upon taking charge of the Bureau September 12, 1901, there were about 5,250 specimens in the museum cabinet, including fossils, coal, clay, lead, zinc, iron, stone, barite and other ores. Since that time there have been added to this collection about six hundred new specimens of fossils, ores, rocks and clays, mainly from the Cambro-Ordovician formations in the south central part of the state.

### LIBRARY.

The library contained about 3,700 books and pamphlets when turned over to the present administration. Since that time there have been added about 280 books and pamphlets, received in exchange for the publications of the Bureau. The library, as well as the museum, is a very important part of the Bureau, but the funds have not been sufficient to classify and build it up as it should have been.

### PERSONNEL OF THE BUREAU.

The following is a list of the persons employed by the Bureau during the period covered by this report with the compensation stated in each case:

E. R. Buckley, Director and State Geologist, $3,000.

H. A. Buehler, Assistant Geologist and Chemist, $660 and $720 since September 1, 1902.

Sydney H. Ball, Assistant Geologist, $720.

A. F. Smith, Assistant Geologist, $720.

C. F. Marbut, Assistant Geologist during summer field season, $100 a month.

F. B. Laney, Field Assistant, $35 a month while in the field, about four months.

Carl Smith, A. T. Sweet and Otto Veatch, Field Assistants, without compensation other than expenses.

T. J. Craig, Draftsman, $45.00 a month; employed about two and one-half months.

Stenographer, $300.

Janitor, $216.

## INTERESTS WHICH THE BUREAU OF GEOLOGY AND MINES REPRESENTS.

Many of the states and territories in which mining is an important industry and nearly all of the foreign countries have a department known as "The Bureau of Geology and Mines," or "The Geological Survey." Among the states, besides Missouri, which support such a department, may be mentioned New York, New Jersey, Maryland, Michigan, Pennsylvania, Virginia, Texas, North Carolina, Alabama, Louisiana, Wisconsin, Ohio, Illinois, Iowa, Minnesota, Oklahoma, North Dakota, Kansas, Nebraska, California and Washington.

That the mining industry of Missouri warrants the maintenance of such a department is shown by the statistics of production of lead, zinc, coal and other products. Missouri ranks first in the production of zinc,

which, according to the State Mine Inspector's report for 1901, amounted to 224,073 short tons, valued at $5,308,671. Missouri ranks second in the production of lead, which, according to the above referred report, amounted, in 1901, to 109,376 short tons, valued at $4,865,518. Missouri ranks first in the production of barite. The production for 1901 was 32,388 tons, with an estimated value of $113,348. She ranks sixth in the production of clay wares, amounting, in 1901, to $4,474,553; sixth in the production of limestone, amounting, in 1901, to $1,362,272, and thirteenth in the production of bituminous coal, amounting, in 1901, to 3,802,088 short tons valued at $4,707,164, according to the report of the United States Geological Survey. These industries alone add each year to the wealth of the state between twenty and thirty millions of dollars. What these industries may mean to the state in the future cannot be foretold. Suffice it to say that the vast underground wealth of this state has scarcely been touched.

## THE FUNCTIONS OF A GEOLOGICAL SURVEY OR A BUREAU OF GEOLOGY AND MINES.

The work which a Bureau of Geology and Mines is called upon to perform may be briefly summarized as follows:

(1st) To determine the relations between the different rock formations at or near the surface of the earth and prepare reports, maps and drawings, giving the thickness, surface distribution, relation to other formations, structure and characteristics of each formation.

(2d) To investigate and publish reports on the economic resources of the state; which include lead, zinc, coal, oil, iron, copper, barite, building stone, clays, cements, road materials, soils, water, etc.

(3d) To collect, name and arrange a cabinet which shall include specimens illustrating the geology and economic resources of the state; also to assist the colleges and schools of the state to make similar cabinet collections.

(4th) To examine ores, rocks, soils and other earthy substances with which the citizens of the state may not be familiar. That is, the Bureau of Geology and Mines should be a department to which a citizen of the state may apply and receive reliable information as to the kind and value of any mineral which he may discover.

(5th) To disseminate, everywhere, correct ideas as to the occurrence, origin and relation of ores, minerals and rocks, with the end in view of increasing the general intelligence of the public on matters related to geology and mining. The Department should be a Bureau of Information to which the outside world, seeking investments, can apply and receive trustworthy information concerning geology and mining in the state.

(6th) To co-operate with and not duplicate the work of the United States Geological Survey. Not only should the Bureau co-operate with the United States Geological Survey, but it should also work in conjunction with the Bureau of Soils, the Bureau of Forestry, the Bureau of Highways and the Bureau of Hydrography. If properly organized, the department should have on its staff men who understand the value of different soils, waters, forestry conditions and road materials as well as geology. Topographic, hydrographic and soil surveys are as truly a part of the work of a Bureau of Geology and Mines as geological and mining investigations.

It is doubtful if it should ever be the province of the Bureau of Geology and Mines to examine and report on individual or private mining properties, except as they constitute a part of a larger report covering the region in which the mine may be located. This is practiced, more or less, it is true, by all Geological Surveys. Yet there is a field for the professional Mining Geologist and it seems that there the Geological Survey frequently oversteps its legitimate field. The investigations of Geological Surveys should cover *districts, regions or counties,* and should not be limited to individual or corporation mining properties.

It is also questionable whether the Bureau should ever make free assays or analyses of minerals, ores, clays or rocks for individuals or corporations. It is frequently necessary for the Bureau to make analyses and assays in the preparation of reports on the economic resources, or even in the progress of the county surveys, and for such work a chemical laboratory is required. There is a field for the professional analyst and assayer, and when the state provides a free assay office, it is encroaching upon the legitimate field of this profession.

Some who have given little attention to geology complain that the reports of the Bureau of Geology and Mines and Geological Surveys contain terms which are technical and obscure; that the publications are unintelligible and consequently of little or no value. It must be recognized, however, that this is not a defect of the reports, but rather of the individual, who apparently is not willing to begin with the elements of the science and work up to a point where he can read intelligently, geological literature. Every time a mathematician writes an algebra he cannot preface it with an arithmetic, although arithmetic is necessary for an understanding of algebra. A person who publishes a novel cannot accompany it with a dictionary. It is supposed that the reader's earlier training will have given him a sufficient vocabulary to make the novel intelligible. Likewise a physicist writing of "Dynamos" cannot preface his book with an elementary treatise on electricity. If a man has use for the text book on dynamos, he will familiarize himself with the elements of

the science before attempting to study the more advanced treatise. If men have not time or sufficient interest in the problems discussed in Geological Survey reports to first acquire the elementary principles necessary to read them intelligently, they ought at least not to condemn the reports for lacking that which they themselves should have acquired elsewhere.

It may be the duty of the Bureau of Geology and Mines to provide a series of reports dealing with the elementary principles of Geology and Mineralogy. In fact, I believe that such a set of reports, taking the place with the public that the primer does with the public school, would very greatly enhance the value of the more or less technical reports of the Bureau of Geology and Mines. Such a set of reports, in which the illustrations were drawn from Missouri, could be used to advantage in the public schools, increasing very greatly the students' knowledge of the physical geography and economic resources of the state in which they live.

Because the geologist connected with a Geological Survey does not attempt to locate ores, as does the prospector, and because he confesses his inability to see a thousand feet beneath the surface of the ground, his work is often condemned. If he cannot tell you what lies beneath the surface, simply by walking through the fields or riding along a road, he is classed among the incompetents. Bear this in mind: "No man, whether he be miner, engineer or geologist, can give an intelligent opinion of the resources of a given territory without first spending days, weeks and sometimes months in examining the hills and valleys with their outcroppings of rock." It sometimes happens that he can then only tell you whether or not the evidence warrants the expenditure of money in prospecting by digging or drilling. From the drill records he will undoubtedly be able to tell you whether or not the contents of the strata are such as to warrant opening a mine.

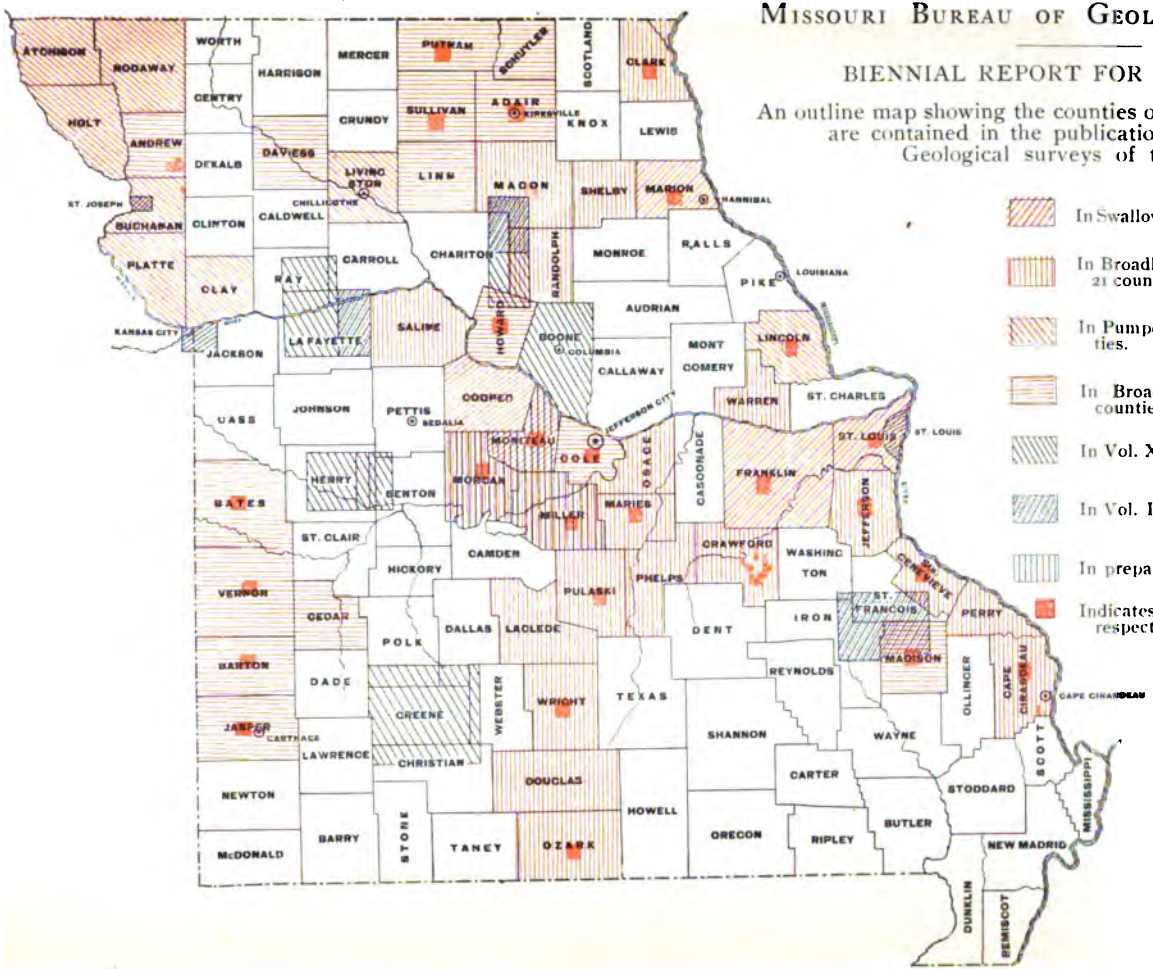
The scientific geologist whose knowledge comes from years of observation on the occurrences of ores in all kinds of mines and under all conditions may be conservative but he is safe. He will discourage speculative enterprises in which the evidence does not warrant investment and will direct capital into channels where there is a greater probability of success. Unwarranted speculation in mining or any other business may benefit the few, but the community or state at large will surely suffer by the inevitable reaction.

The Bureau endeavors to keep as close as possible to the facts and upon these alone do we base our judgment of the mineral prospects of an area upon which we may be called to pass judgment.

# Missouri Bureau of Geology and Mines.

## BIENNIAL REPORT FOR 1901-02, PL. II.

An outline map showing the counties of which special reports are contained in the publications of the earlier Geological surveys of the State.




In Swallow's Report of 1855, 5 counties.

In Broadhead's et al. Reports of 1871, 21 counties.

In Pumpelly's Report of 1872, 8 counties.

In Broadhead's Report of 1873, 15 counties.

In Vol. XII.

In Vol. IX.

In preparation.

Indicates that maps are printed of the respective counties. 26 counties.

## COUNTY REPORTS.

There are sixty-three counties in Missouri for which reconnoisance or complete geological reports have never been published. Eleven of these have been reported upon in part in the earlier publications of the Bureau, but for fifty-two of the counties there are no published reports. This situation may be attributed very largely to the disconnected, interrupted life of the Bureau brought about by changes in administration.

The accompanying map (Plate II) will give the reader an idea of the area which has been covered by the earlier surveys.

Under the present administration it is the plan to begin a thorough, detailed survey of these counties, publishing reports on each as soon as the manuscripts, maps and drawings can be prepared. These reports will consist of descriptions of the rock formations and mineral resources; geological map of the county; drawings showing the vertical succession of the beds and cross-section showing the structure of the region; and photographic illustrations of typical rock exposures. The descriptions of the formations and mineral deposits will be made in sufficient detail to be of assistance to the prospector in locating and working ore bodies.

The nature of these reports can be better understood by an examination of the following brief outline of the report on Miller county, which is now in press:

### The Areal Geology of Miller County.

I.—Introduction.
- (A) Area.
- 1. Location.
  - (a) Latitude and longitude. (b) Geographical position. (c) Position and relation to Ozark Uplift. (d) Position with respect to Lead and Zinc districts.
- 2. Size and shape.
  - (a) Length and breadth. (b) Number of square miles. (c) Relative size.
- (B) Aim and scope of work.
- (C) Methods of field work.
- (D) Acknowledgments.

II.—Bibliography With Resume of Work.

III.—Physiography.

(A) Types of surface relief.
1. River bottom land areas.
2. The broken or hilly areas. (1, Brakes. 2, Ridges.)
3. The uplands, prairies, or table land areas.
4. The relation of physiographic types to industrial and social conditions.

(B) Caves and sinks.
1. Recent.
2. Ancient.

(C) Relative elevations.

(D) River Systems.
1. The Osage.
(a) Drainage area. (b) Direction of flow. (c) Amount of fall. (d) Volume. (e) Character of valley and flood plains. (f) Fords. (g) Tributaries.
2. The Moreau.
(See sub-letters under (1) above.)

(E) Divides.

IV —Stratigraphy.

(A) Undifferentiated Cambrian and Ordovician.
Proctor Limestone. (Fourth Magnesian Limestone of Swallow.)

(B) Ordovician.
1. Gunter Sandstone. (Third Sandstone of Swallow.)
2. Gasconade Limestone. (Third Magnesian Limestone of Swallow, in part.)
3. St. Elizabeth Formation. (Includes Second Sandstone of Swallow and also part of Swallow's Second and Third Magnesian Limestones.
4. Jefferson City Limestone. (Second Magnesian Limestone of Swallow, in part.)

(C) Devonian (probable Sac Limestone).

(D) Carboniferous.
1. Lower Carboniferous.
(a) Upper Burlington Limestone. (Lower Beds.)
2. Upper Carboniferous.
(a) Graydon Sandstone. (b) Coal Measure Shale. (c) Coal.

(E) Pleistocene.
1. Glacial boulders.

(F) Recent.
1. Soil.
2. Travertine.

(G) General section.

V.—Geological Structure.

(A) Folding (Ill. By Cross section).

(B) Faults (Ill. By Cross section).

(C) Unconformities (Ill. By Cross section).

1. Proctor-Gunter.
2. Upper Burlington.
3. Graydon Sandstone.
4. Coal Measure shale.
5. Recent.

VI.—Geological history.

VII.—Minerals and Rocks.

VIII.—Economic Geology.

(A) Lead and zinc; (B) Barite; (C) Coal; (D) Building stone; (E) Lime; (F) Cement; (G) Sand; (H) Clays; (I) Road materials; (J) Iron; (K) Gold and silver; (L) Copper; (M) Oil and gas; (N) Soils; (O) Water supply.

IX.—Resume and Conclusion.

The present published Geological Map of Missouri was compiled from surveys of about one-half of the counties in the State and necessarily contains many inaccuracies. It has been broadly generalized and the distribution of many of the formations is very inaccurately outlined. One of the results of the survey of the counties will be the preparation of accurate geological county maps, from which in due time a reliable state geological map can be constructed.

During the last year one county was entirely, and two more were partly, surveyed. The preparation of the county reports, exclusive of topographic maps and printing, will cost all the way from $1,200 to $2,500, depending upon whether the geology is simple or complex. Five or six counties should be surveyed each year and an adequate appropriation made therefor. If the present policy of the survey is carried out this work in the end will cost the state about $150,000. One-fifteenth of this should be appropriated each year for fifteen years and a consistent policy maintained by which each county will be eventually surveyed and reported upon. It is unnecessary to enumerate the states where this work was done ten or fifteen years ago or call attention to the states that are now engaged in this undertaking. Pennsylvania and Iowa are two well known examples. In the former state, reports have been made covering all the counties. In the latter state only about two-thirds of the counties have been reported upon and the work is being carried steadily forward.

The order in which the counties are surveyed should be left entirely to the discretion of the Board of Managers, and each representative and

senator should assist in this work with a knowledge that his county will eventually receive the same attention as the other counties which are now being surveyed.

## SPECIAL ECONOMIC REPORTS.

The second function of the survey, mentioned above, was the investigation and reporting upon special resources, such as coal, lead and zinc, barite, building stone, clays, cements, road materials, etc. Reports of this nature are represented by the volumes of this Bureau on "Lead and Zinc," "Coal Deposits," "Clay Deposits," "Iron Ores" and "Mineral Waters." The demand for these reports has been so great that the editions of all these reports have been exhausted. There are constant requests from all parts of the country for these reports, yet we have none with which to supply the demand. Some of these volumes should be rewritten and a new edition published, if it is expected that this department shall do its utmost to interest the outside world in the rich mineral resources of the state. Logically, these reports should follow the completion of the county reports, but so long have these areal reports been delayed and so great is the demand for the economic volumes, that this department must devote a part of its funds to the preparation and publication of economic reports.

The revision and republication of the reports on "Lead and Zinc," the "Clay Deposits" and "Coal" would meet a very strong present demand for information on these resources.

Besides the republication of these reports, new special reports should be issued on "Barite," "Pyrite," "Cements," "Road Materials' and "Solis." These subjects should be investigated in all sections of the state and the results of these investigations published. In this way information can be gathered and disseminated which can be obtained in no other way.

During the last year the Bureau has begun the investigation of the "Quarrying and Building Stone Industry," and, if nothing unforeseen occurs, a report on this subject will be ready for distribution sometime during the next year. The following is a brief synopsis of this report:

### The Quarrying Industry of Missouri.

I.—Introduction.

II.—Demands and uses for stone.

(A) Constructional Work.

(1) Building; (2) Street constructions; (3) Monuments; (4) Bridges and culverts; (5) River and lake shore constructions; (6) Railroad ballast; (7) Black boards, sanitary wares and tables; (8) Miscellaneous.

(B) Manufacturing.

(1) Cement; (2) Quick lime; (3) Carbon dioxide; (4) Abrasives and polishing powders; (5) Flux; (6) Gannister; (7) Miscellaneous.

III.—Necessary Considerations in the Selection of Stone for these Various Purposes.

(A) External causes of decay.

(1) Agents promoting mechanical disintegration. (2) Agents promoting chemical decomposition.

(B) Inherent qualities of the stone.

(1) Mineralogical composition.
(2) Chemical composition.
(3) Texture.
(4) Hardness.
(5) Strength.
(6) Structure.

IV.—Methods of Determining the Value of a Stone for Building or Other Economic Purposes.

(A) Quarry observations.
(B) Observations on buildings, monuments, pavements, etc.
(C) Laboratory tests.
(1) Chemical.
(2) Microscopical.
(3) Physical.

(1) Crushing strength. (2) Transverse strength. (3) Elasticity. (4) Specific gravity. (5) Porosity. (6) Weight. (7) Effect of freezing and thawing. (8) Effect of acids.

V.—Description of the Granite and Porphyry Areas and Quarries.

VI.—Description of the Sandstone Areas and Quarries.

VII.—Description of the Limestone Areas and Quarries.

VIII.—Areas from which Suitable Stone for Different Uses May be Obtained.

IX.—Discussion of the Results of the Physical Tests on Stone from Missouri Quarries.

X.—Minerals and Rocks. Different Kinds and their Composition.

Economic reports similar to the above cost for field work and publication, various amounts depending on the importance of the industry. The cost will probably range from $3,000 to $10,000.

## COLLECTING CABINET SPECIMENS.

The third function of the Bureau is to collect, name and arrange a collection of specimens illustrating the geology and economic resources of the state. Somewhere in the state there should be a collection of the ores, minerals, rocks and fossils of Missouri, to which the public may have access and which represents truthfully the state's clay, stone and mineral resources. There is no department better equipped for making this collection than the Bureau of Geology and Mines. This collection may be made incidentally as the field work for the various reports is being carried on.

The collection now in the Bureau is only a fair representation of the mineral resources of Missouri. The industrial side of the exhibit has not been strongly enough emphasized. It is intended during the coming years to make this feature of the Cabinet more prominent. It is our purpose to have in this cabinet collections of ores from all the mining camps in the state; clays and clay products from all the brick, tile and terra cotta plants; building stone from all the quarries; cements from all the cement factories; and quick lime from all the lime kilns. It is not intended to make this a collection of oddities, in the way of beautiful or peculiar crystal growths, but to make it a commercial exhibit which will be of interest to the miner, investor and educator. It is our purpose to put the collection in such shape that people, who are not able to visit all the mines, may view this collection with an understanding that they will see fairly exhibited the mineral resources of the state. The specimens contained in the exhibit will be the ordinary and not the exceptional products of the mines. It is intended that these exhibits shall be accompanied with maps, charts and reports, which may further assist the investor and student in obtaining a knowledge of the resources of this commonwealth.

During the process of collecting, many duplicate specimens may be, with little additional trouble, collected and used for making up type sets of specimens to be sent to the colleges and prominent high schools of the state. I believe that it would be within the province of this Bureau to employ a man during the year to collect and prepare sets of specimens for this purpose. Some of the higher institutions of learning are woefully deficient in this kind of material for the use of classes in geology and physical geography. All of these functions cannot be performed with the very limited appropriation which has been allotted to the Bureau in the past. For this work, however, I believe some provision should be made.

CARD CATALOG RECORD CASE NO. 1.

## EXAMINATION OF SPECIMENS.

Many of our citizens are unfamiliar with the appearance of the common ores which occur abundantly in some sections of the state. They may frequently pass by a deposit of zinc blende or even galena without recognizing its value. It is one of the duties of this Bureau to examine all specimens sent to it by citizens of Missouri furnishing such information as it can relative to the kind and value of the mineral. It would be very desirable for the Bureau to make free analyses and assays of specimens, if it were not for the fact that this privilege would be greatly abused and that it is an infringement upon the field of the professional assayer and analyst. The Bureau should furnish advice as to whether the specimens submitted are of such a nature as to warrant an assay, but the determination itself should be left to the professional assayer.

In connection with the preparation of reports on economic resources and areal geology, there are a great many analyses of rocks and ores necessary. For this purpose the Bureau should be provided with its own laboratory. Important determinations can be made more carefully, are more reliable and cost less than when they are made in other laboratories. If the Bureau has a well equipped laboratory, the cost of making assays and analyses would be comparatively little.

The Bureau is not at the present time provided with a chemical laboratory, but it is hoped that within a year or two the necessary equipment will be provided.

## BUREAU OF INFORMATION.

In order to give out information, it must first be collected. When collected, it must be stored away for future use. The value attached to such information depends very largely upon the ease with which it can be obtained when wanted. A Chicago gentlemen, interested in mining land in Sec. 7, T. 32N., R. 28W., writes to the Bureau and asks for such information as we have bearing upon the mineral resources of the above described land. Another gentleman writes for information concerning lead in Shannon county (R's. 3W to 6W., T's. 26-29, R's 2W., T's. 28 and 29, and R. 1W., R. 28.) These illustrate the two classes of inquiries which are continually coming to the department for replies. Information which will assist in answering these inquiries is also constantly coming to the Bureau through correspondence or through personal investigations by members of the Bureau staff. The question which presented itself to

the Director upon taking charge of the Bureau was, how to devise a plan for classifying and storing this information for future use. It was recognized that in any case the process of accumulating the necessary information would be slow and years might elapse before the records would very greatly assist in answering inquiries similar to those mentioned above. Nevertheless it was believed that a beginning should be made.

As a result of much thought and planning a combination note book and card catalogue system was adopted. The note books adopted are of two kinds, designed for areal and economic work. These books are numbered consecutively and the pages are also numbered. In these books are recorded, in ink, the observations taken while in the field. The observations are necessarily of a miscellaneous character and are arranged in the books in the order in which they are made. One page may contain notes on coal found in Sec. 5, T. 52, R. 18E., while the opposite page may contain a discussion of lead or zinc in Sec. 16, T. 44, R. 17W. These note books accumulate from year to year, but no mind can keep track of the information which they contain or the page of the note book in which it occurs. At least no one on the staff but the man who recorded the information knows where to find it. There are in the Bureau to-day several hundred note books containing observations on the geology and economic resources of the state which, on account of the time it would take to glean special information from them, are almost valueless.

That the information collected may be preserved and transmitted to succeeding administrations, the card catalogue has been introduced. To keep this information in such shape that all questions similar to the above—one about lead and zinc in a township or county and the other about the mineral resources of a particular section or tract of land—can be answered quickly and accurately, two separate cases have been provided. These cases are shown in the accompanying illustration and will be described separately.

The first case (Plate III.) contains sixteen drawers or trays. Each of these are labeled with the numbers of certain townships. For example, the label on the upper left-hand drawer reads, "Townships 16 to 21;" the one below that, "Townships 22 to 24;" and so on, as shown in the figure. In each of these drawers are white cards five by eight (5x8) inches in size, on which is recorded the information which it is intended to preserve. Besides these cards are others having a yellow color and still others which are blue. The yellow cards have numbers on them corresponding to the numbers of the townships on the outside label and are placed in ascending order from the front to the back of the tray. Between the yellow cards there are from 35 to 52 blue cards with numbers

MISSOURI BUREAU OF GEOLOGY AND MINES. BIENNIAL REPORT, 1901-02, PL. IV.

S. 15 T. 44 R. 17

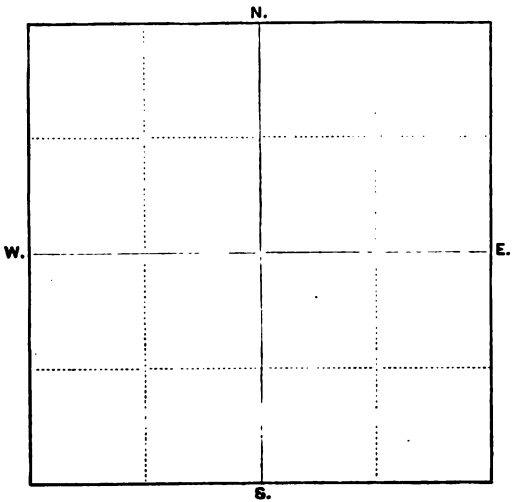
Center S.Line S.W.1/4. Hot Springs Mine.
GALENA and BLENDE in Rolla formation. M.B.27 p.89. M.B.37 p.53.

S.W.40.
BLENDE and GALENA in Rolla formation. New discovery. M.B.27 p.89 M.B.37 p.65.

S.E.40. Hershey Mine.
GALENA and BLENDE in Coal Measure shale. M.B.27 p.89,M.B.37 p.17.

17W

T44




RECORD CARDS USED IN CASE I.—FRONT AND BACK OF CARD.

marked on the tabs referring to all the different ranges in which the town, indicated on the yellow tab, occurs in Missouri. Back of the blue cards are inserted the white cards, one for each of the 36 sections in a township. These cards are shown in the accompanying illustration, Plate IV.

Should information be received that lead had been found in the S. W. ¼ of the N. E. ¼ of Sec. 26, T. 38, R. 20W., there would be recorded on the card for this section, briefly, all the information at hand, giving the authority and the date. If the information was collected by a member of the survey and recorded in a note book, the same summary of the occurrence would be made on the card, but, in addition, the number and page of the note book would be recorded. On the back of each card is a diagram representing a section of land, and here the location of ore is indicated by a symbol.

Where the information is stored in this way an inquiry as to the mineral resources of a given section of land can be answered in the space of a few seconds, while it might take hours to find the desired information if one were compelled to look through records, as kept in field note books.

The second case also contains sixteen drawers or trays carrying cards six by four (6x4) inches in size. By glancing at Plate V. it will be observed that each of these trays has a distinct and separate label. One tray is marked "Clay," a second "Lead and Zinc," a third "Coal," etc. All information concerning these various resources, coming to this office, is filed in one of these trays. These trays contain one set of record cards and another set of tab cards. A set of tab card consisting of one for each county is included in each tray. A record card is used for each section of land in the county, and in the tray there are placed back of each county tab card as many cards as there are sections of land in the county. The memorandum is recorded on these cards, but it is usually briefer than that on the cards of Case I. The notes are often made to refer back to Case I, as well as to the note books. The value of this case comes from having in a separate tray all the information collected bearing upon each of the mineral resources of the state. The cards used in this case are shown in the accompanying illustration, Plate VI. By referring to this case one can answre in a few moments any inquiry for information on the lead deposits of Dent or any other county, provided such data have ever been collected.

These two cases provide the Bureau with the most efficient and practical system of keeping a record of the resources of the state that has yet been devised.

It may be well to state that it is not expected that these card record cases will be of any more than occasional value for several years. Each year, however, as information is stored away in them, they will increase in value. For the next ten years they will constitute reservoirs, or the houses, wherein the grain to be used in future years will be stored. A record of this kind, carefully preserved, will eventually be invaluable to the citizens of Missouri, where the mineral resources are of such a diversified character.

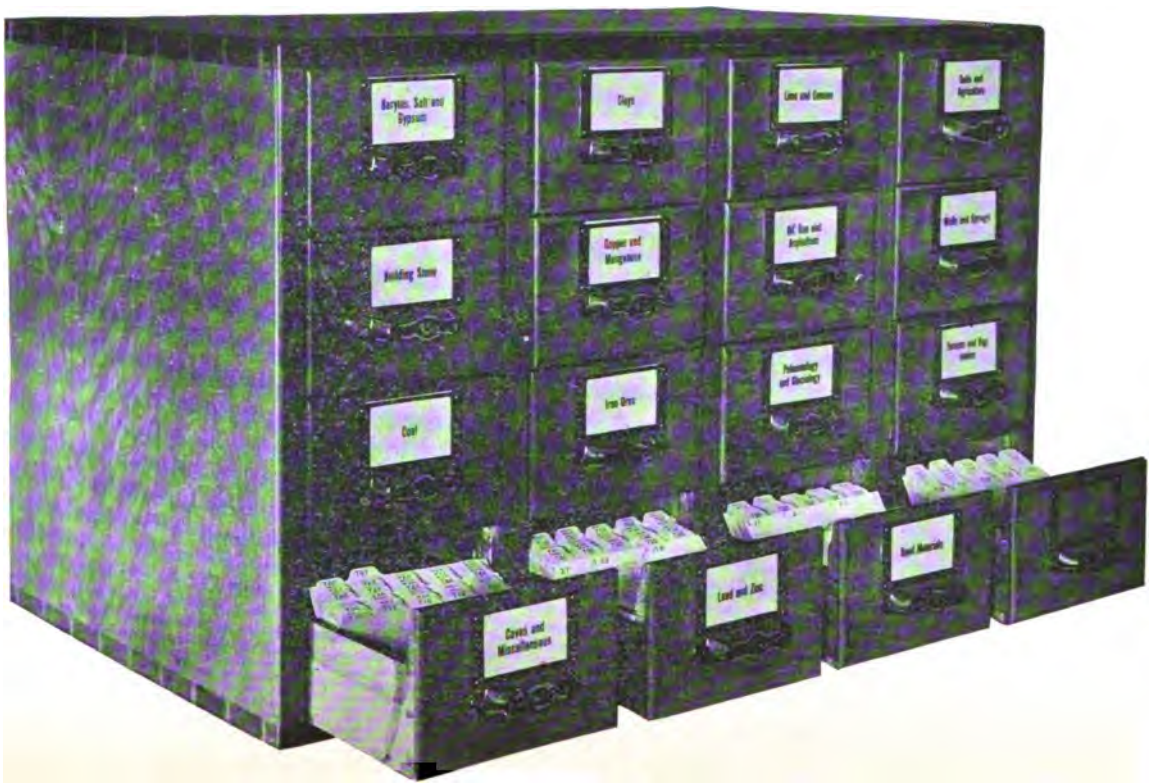
This card record system has been extended into other departments of the Bureau. A case with nine trays, carrying cards three by five (3x5) inches in size, has been provided for keeping a record of all publications received and distributed by the Bureau. The publications of the Bureau are sent to all parts of the world, and from all countries we are receiving scientific publications in exchange.

On the front and at the top of the cards used in this case is written the name of the state or country, the name of the city and the name of the person or organization to which the bureau publications are sent. On the lower half of the card is a list, by number, of the reports which have been published by the Bureau and a list of those which will probably be issued during the next ten or fifteen years. A cross drawn through any number indicates that this volume has been sent to the address written on the card. On the back of the card is a record of the volumes received from the individual or society whose name appears on the front card. This system of recording exchanges enables us to keep a record of all reports distributed, with the name and address of the party to whom sent, and also a record of all publications received in exchange.

Another four-tray card record case, with cards four by six inches, is used for keeping a permanent inventory of stock and the accounts of the Bureau. The stock of the Bureau is classified as permanent and temporary. In the first class are included desks, chairs, cabinets, instruments, etc. In the second are included note books, stationery, chemicals, etc. The permanent stock is distributed through the building, in the library, museum and offices. Each article in a room is charged against that room, and the person to whom the room is assigned is responsible for the furnishings and instruments in that room.

The money appropriated for the maintenance of the Bureau is expended in general in three directions: (1) for salaries, (2) for traveling expenses and (3) for supplies. A record of the amounts expended for these purposes is kept on separate cards, and it requires only a few min-

MISSOURI BUREAU OF GEOLOGY AND MINES. BIENNIAL REPORT, 1901-02, PL. V.




CARD CATALOG RECORD CASE NO. 2.

utes for one to ascertain the amount which has been expended in all or any one of these directions.

Cards are also kept which show the amount which has been drawn by each member of the Bureau for each of these purposes. Accounts are also kept with various manufacturing concerns and local companies from whom supplies are regularly purchased. Accounts are also kept with instruments, stationery, furniture, etc., so that one can ascertain very quickly the amount which has been expended for each of these purposes.

Before the records of the Bureau are complete, two more card cases must be provided, one for a record of the cabinet specimens in the museum and the other for cataloging the books and pamphlets in the library. Every specimen should have a number and every book should be lettered and numbered. The location of specimens and books in the cases or on the shelves should be recorded on the card with which they are catalogued. The photographs, plates, cuts, maps and everything else should be thus indexed.

It is our purpose to obtain these additional cases and continue the cataloging as rapidly as time and money will permit. After they are finally in shape, they can be maintained easily and at a moderate expense.

The time which will be saved to the members of the Bureau will many times compensate them for the trouble and pains necessary to keep the system up. It would even be profitable to employ a stenographer especially for this work, if it could not be carried on by the stenographer who does the general work of the office.

The above discussion has carried us somewhat away from the Department as a Bureau of Information, but the entire card record system is so intimately connected that one part cannot well be discussed without the other.

Upon any subject that pertains to the organization or work of the Bureau, whether it be a record of drill holes in St. Francois county or a record of the accounts for December, the card system places us in a position where we can answer inquiries quickly and accurately.

## CO-OPERATION WITH THE U. S. GEOLOGICAL SURVEY.

It is the policy of this Bureau to co-operate with and keep in close enough touch with the U. S. Geological Survey to know what work is contemplated for Missouri, so that there will be no chance for duplication. This year there has been expended by the U. S. Geological Survey, in geological and topographical work in Missouri about $8,000, or a sum nearly equal to that appropriated by this state for geological work for the same period. Five thousand dol-

lars of this has been spent in a geological investigation of the Joplin district, and the other three thousand in making a topographic map of the so-called Versailles sheet, which includes a portion of Morgan, Miller, Camden and Moniteau counties.

An idea of the importance of co-operation between the state and United States Surveys will be obtained by reading the following extracts quoted from the twenty-second annual report of Dr. Charles D. Walcott, the Director of the United States Geological Survey:

"Under terms varied to suit the conditions of each special case, agreements involving co-operation of some sort have been made between the Director and State officials of Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, North Carolina, Georgia, Alabama, Ohio, Wisconsin, North Dakota, Colorado, Nevada, Idaho and Arizona."

"The States benefit by co-operation in geology and allied scientific activities by the resulting reduction in expense of administration and the possibility of a specialization in detail otherwise unobtainable."

"The Federal Bureau benefits by the great increase in funds available for the extension of its legitimate operations. This Bureau is charged with the duty of making a topographic and geologic map of the entire area of the United States, as well as of studying its water resources and reporting on its other economic products. The expense of this work to the Federal Treasury is reduced by the amount appropriated by the varioue States for co-operative surveys. All agreements for co-operation being on the basis of equal expenditure, they necessarily reduce by one-half the cost to the Federal Government of conducting its operations. An additional benefit of co-operation is the hastening of the completion of the topographic map, which thus renders it available at an earlier date as a base for the further studies of economic resources—geology, hydrography and the classification of lands."

"One important point to be considered in all such work is that the general plans and methods of the Federal Survey can not be set aside on account of State co-operation. At the present time the funds available for co-operation are so limited that its further extension is dependent upon increase of appropriations by Congress. It is against the policy of the Survey that work on important areas or subjects should be stopped in order that co-operation with individual States may be extended. The Director is willing to enter in a co-operative agreement only when the interests of the country as a whole will be benefiitted."

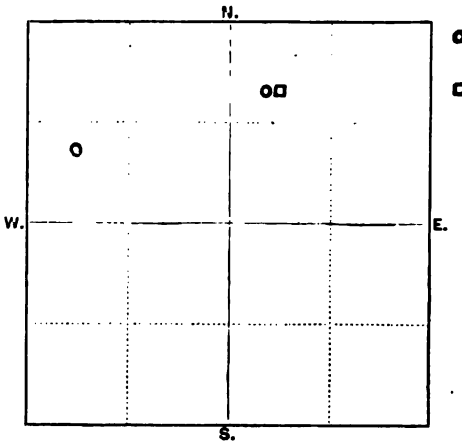
"The total cost of mapping the State of Massachusetts was $107,845. This is exclusive, however, of much of the primary triangulation, which

S. 3 T. 41 R. 16

N.CENTER of S.W.1/4 of N.W.1/4
BLENDE in Coal Measure shale; shines. N.B.33,p.29.

S. CENTER N.W.1/4 of N.E.1/4.
GALENA and BLENDE in Coal Measure shale pocket. N.B.25,p. 17. N.B.33,p.9.91. N.B.32,p.97.

T41




RECORD CARDS USED IN CASE 2, SHOWING FRONT AND BACK OF CARD.

was executed by the United States Coast and Geodetic Survey. The total average cost of this work was at the rate of $12.90 per square mile." * * * "The total expense of making the topographic survey of New Jersey was $54,744.58. Of this sum the United States Geological Survey expended $35,073.98. The total cost of mapping the State was at the rate of $6.93 per square mile, exclusive, however, of three-fourths of the primary triangulation, which had been previously executed by the United States Coast and Geodetic Survey." * * * "Co-operation with the State of Pennsylvania was commenced in the year 1899 by the appropriation for the two years, 1899-1900, of the sum of $40,000, which has been expended under the supervision of the State commissioners, George W. McNees, Simon Harrold and F. D. Barker." * * * "Co-operation with the State of North Carolina was commenced during the current year by the allottment of $20,000 for the two years, 1901-1902, by Governor Charles B. Aycock from the funds of the State agricultural commission." * * * "Co-operation with the State of West Virginia was commenced during the current year as a result of the appropriation by the last legislature of the sum of $30,000 for the two years, 1901-1902."

"The appropriations made by the States for co-operative surveys are accepted only for actual field work, in which are included the services of temporary employees, who are usually residents of the State, and the living and traveling expenses of the field force. Thus the amount appropriated by the State is returned to the people thereof. The appropriation of the Federal Government is devoted chiefly to paying the salaries of the permanent employees, a small portion of it being expended on general administration and a considerable portion on field and office work. The field work of the co-operative topographic surveys is invariably in charge of topographers or assistant topographers of the United States Geological Survey, who are appointed, on the recommendation of the United States Civil Service Commission, by the honorable Secretary of the Interior. All assistant surveyors, as levelmen, transitmen, etc., and such helpers as rodmen, teamsters and cooks, are employed, under regulations of the Department of the Interior, in the locality in which the work is being done and under the terms of a signed application and agreement, which they must file when seeking such employment."

"The topographic map is the base upon which the field investigations of the geologists and hydrographers are recorded, and which makes possible a broader and more general study of the results than is otherwise practicable. It was at once realized by State officials to whom such investigation had been assigned that an accurate and comprehensive performance of their duties was impossible without an adequate topographic base map. The expense of making such maps, however, was found to

exceed in most instances the resources procurable from state aid, and the lack of skilled men required in making such surveys was a barrier not easily surmounted. Competent topographers are rare, and there is little inducement for young engineers of ability to make this their profession outside of the work of the General Government while there is so little opportunity for steady employment elsewhere. By co-operating with the Federal Survey it was apparent that the opportunities for systematic mapping would be greatly increased in the States availing themselves of the personnel and administrative knowledge of the Survey."

"Accordingly, the first important step in the development of the existing system of co-operation was in connection with the extension of topographic mapping. The benefits to the State from co-operation are numerous. It gains a complete topographic map of its area, which is of importance to the development of its numerous economic resources and greatly facilitates the study and perfection of all engineering plans and works. Among other uses of the topographic maps are the following:

1. EDUCATIONAL.—(a) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

2. PRACTICAL.—As preliminary maps for planning engineering projects. Highways, electric roads, railroads, aqueducts and sewerage plants may be laid out on them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs and routes of canals may be ascertained from these maps.

3. POLITICAL.—In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

4. ADMINISTRATIVE AND MILITARY.—In all questions relating to Federal or State administrations of public works, as canals, reservations, parks, highways and as military base maps on which to plan works of offense, defense, camps, marches, etc.

5. STATISTICAL.—As base maps for the graphic representation of all facts relating to population, industries, products or other statistical information.

6. ECONOMIC.—As a means for showing the location, extent and accessibility of lands, waters, forests and valuable minerals. In this respect these maps are indispensable to State and Federal bureaus, and to owners, investors and corporations.

In addition, as an incident in the making of a topographic map, monuments are established throughout the State, the positions of which are accurately determined by geodetic methods and which serve as datum points for all other Government, private and cadastral surveys. There are also established throughout the State bench marks or permanent

monuments which furnish datum elevations for the future determinations of height in connection with all public or private engineering works. Meridian marks are established at each county seat, which aid local and county surveyors in determining the declination of their compasses and which thus greatly facilitate the search for old property lines."

"The maps that result from these co-operative surveys show, in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief, or surface forms, printed in brown, including the shapes of the hills, valleys and ravines, their elevations and depressions, and the slopes of every rise or fall in its surface of the land.

The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating States have the benefit of this publication without further expense, and the residents of the State, as well as its officials, may purchase the maps at rates of 5 cents per sheet or $2 per hundred."

Co-operation should extend beyond the United States Geological Survey and include the Bureau of Soils, the Bureau of Forestry, the Bureau of Highways and the Bureau of Hydrography. The work of all of these Federal bureaus is valuable and their attention should be directed to the state of Missouri. A soil survey by the United States Bureau of Soils was begun last season in the southern part of the state. A little assistance or encouragement in this work by the Bureau of Geology and Mines might induce the department to continue indefinitely this survey. The other Bureaus have done very little work in Missouri. Correspondence with the Department of Hydrography leads me to believe that before the end of next season stations for taking hydrographic observations will be established.

## RELATION TO SCIENTIFIC ORGANIZATIONS, THE UNIVERSITY, ETC.

This Bureau should not only direct its attention to the development of the mineral resources of Missouri, but it should also interest itself in the dissemination of Geological and other Scientific information which may lead to a better understanding, on the part of the people, of the geography and geology of the state. The scientific and engineering societies

of St. Louis and Kansas City ought to be interested in the work of the Bureau and the Bureau ought, in turn, to assist in sustaining these organizations.

Much can be done to aid the work of the Bureau by the Business Men's organizations of such places as Joplin and Aurora through friendly and social intercourse between the members of each organization. These clubs can assist the Bureau very greatly in its work in the districts in which they are located and the Bureau can undoubtedly, in a measure, contribute to the success of their mining enterprises.

There are many men in the state, some of whom are members of local scientific societies, who have a deep interest in the scientific work of the Bureau. These men can aid the Bureau very greatly in the communities in which they live, and they can rest assured that the Bureau will always be glad to assist them to any information which it may possess.

It is hoped that the Bureau may be able to avail itself of the service of the young men graduating from the University and School of Mines, who have had special training in geology and mineralogy. However, it requires a thorough knowledge of geology and mineralogy, in its many branches, to fit a person for an assistant's position in the Bureau. The state should provide abundantly for the training of young men along these lines so that it will not be necessary to employ men from other states. Thus far the Bureau has employed all the different men from the University and the different colleges of the state, who have had the necessary training, to perform the duties of field assistant. It is of mutual advantage to the Bureau and the University to have men employed in the work of the Bureau who have been trained at the University of Missouri.

## PETITIONS.

The forty-first general assembly amended Chapter 110 of the Revised statutes of 1899 by adding the following new section, known as section 7503b:

"Section 7503b. On presentation of a petition to the state geologist, signed by not less than fifty freeholders who reside in the neighborhood of lands situated in any county in this state which they may believe to contain valuable or have found valuable ore, clays, rocks, coal, mineral, oils or mineral matter, said petition being certified by the clerk of the county court in which the petitioners reside to contain the names of fifty freeholders residing within the neighborhoods of the lands, which lands shall be described in the petition according to government surveys, is shall be the duty of the state geologist in person or by assistant, as soon as practicable to examine and inspect said lands and make a report

and map as to existence on said lands of valuable ores, clays, coals, mineral, oils or mineral matter found and embody the same in his report now directed to be made by section 7503, Revised Statutes of Missouri, 1899."

In compliance with these instructions the State Geologist has answered in person all petitions for the examination of mineral lands and furnished to the parties interested a written report covering the results of such examinations. As far as time would permit the State Geologist has also answered requests, which were unaccompanied by a petition, for an examination of mineral lands. In these cases the parties making the request were required to furnish satisfactory evidence that there was a reasonable expectation of finding mineral.

The petitions, as a rule, came either from local companies or from communities interested in prospecting for oil, coal, lead and zinc, or in developing stone quarries. The following is a list of the petitions received and copies of the answers returned under the present administration:

PETITION OF J. W. GRAYSON ET AL., NEWBURG, MO.

Petition to examine following described lands: S. ½ S. E. ¼ of sec. 33, T. 37, R. 9 W; the N. E. ¼ of the N. E. ¼ and the N. W. ¼ of the N. E. ¼ of sec. 4; the S. W. ¼ of the N. E. ¼, S. E. ¼ of the N. W. ¼ N. W. ¼ S. E. ¼ of sec. 3, T. 36, R. 9 W.; and the S. ½ N. W. ¼ and S. W. ¼ of N. E. ¼ of sec. 36, T. 37, R. 9 W.

To the above petition the following report was submitted:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF NEWBURG.

In response to a petition, signed by J. W. Grayson and 72 others, I visited the land above described, making an examination of the different prospects and studying the relation of the various formations of that region. The examination of the lands was made in company with John A. Chambers and J. L. Buskett.

The strata which outcrop in this area consists mainly of what have been known as the Second Saccharoidal Sandstone, and the Third Magnesian limestone. A large part of the ridge lands of this area are covered with soil which is underlain by chert or sandstone beds of the Second Saccharoidal Sandstone formation. As near as could be determined from aneroid barometer measurments, the sandstone formation is about 140 feet thick. The aneroid barometer indicated that the bottom of the sandstone formation was normally about 160 feet above the level of Little Piney River at Newburg. In some places, however, the sandstone occurs at a much lower horizon, coming in somewhat abruptly along the sides and heads of some of the draws. In one instance, sandstone was observed

on one side of a draw at the same elevation as the magnesian limestone on the other side. There is evidence in this region, as elsewhere in the Ozark uplands, of mechanical deformation of the beds. Whether or not the displacement of the sandstone blocks can be attributed to the forces by which the Ozark uplift was formed, still remains in doubt.

The finding of misplaced strata and the observations which go to show that some of the third magnesian limestone beds are vesicular or filled with small drusy cavities, give evidence that the rock at some places may have possessed the conditions which are favorable for the concentration of lead and zinc ores.

The numerous springs which occur in this area and the abundance of water flowing in the Little Piney River, give evidence of circulating waters, which are a necessary agent in the deposition of ore bodies in rock such as occurs in this region. That the circulating waters of this region, at one time or another, have carried lead and zinc ores in solution, is shown by the fact that these ores actually occur as a replacement in the Third. Magnesian limestone formation.

The problem which presents itself to the prospector is to find a locality where conditions have been favorable for the concentration of the ores into bodies of workable size.

* * * * * *

During the afternoon of the first day at Newburg an examination was made of such portions of sec. 36, T. 37, R. 9 W., as are mentioned in the above descriptions. In the S. W. ¼ of the N. W. ¼ of this section a drift has been run into the hillside following zinc ores, both the sulphide and carbonate, with the hope of encountering a workable deposit. The drift is about 200 feet long and is almost level. It was run in on very hard ground, consisting partially of chert or flint. In a number of places in the drift zinc sulphide and zinc carbonate occur, filling or lining small irregular cavities. These ores of zinc usually occur together. The carbonate forms a periphery around the blende and is undoubtedly an alteration product of it.

From such observations as it was possible to make, it appears that the zinc ore does not occur in any well defined sheet or vein. It appears, however, that the bed of magnesian limestone, in which the drift has been run, contains numerous cavities and irregular clay openings, in many of which ore has been deposited. The clay which occurs with the zinc, however, has in all probability been brought in and deposited subsequent to the original deposition of the zinc ore.

In one place, near where the drift branches, the flint rock is somewhat brecciated. At this place, both the carbonate and sulphide of zinc

were moderately plentiful. The mineral in the clay pockets is ordinarily galena and not zinc sulphide or blende.

At this place the base of the sandstone formation is about 160 feet above the level of the Little Piney, which flows at the foot of the hill in which the drift is located. The first galena found at this place during the early days was picked up about 15 feet below the contact between the sandstone and the limestone beds. About 50 or 60 feet below this contact another horizon was examined, in which irregular masses of carbonate and sulphide ores were observed, partly filling the irregular cavities of the rock.

In general, at this place, lead and zinc ores have been found at three different horizons in a thickness of about 160 feet of Third Magnesian limestone.

If I were to recommend anything in the way of development at this place, I would suggest that search be made for a possible broken or brecciated zone in the vicinity of the present drift. The only evidence of such a zone was the small width of brecciated chert found near the place where the tunnel branches.

* * * * * *

On the second day, the 19th of April, an examination was made of the S. E. ¼ of the N. W. ¼ of sec. 3, T. 36, R. 9 W., on which is located a prospect in which Mr. J. L. Buskett is interested. The barometer showed that the sandstone at this place was normally about 165 feet above the Little Piney River at Newburg. The top of the Buskett shaft was found to be about 135 feet above the river. Thirty feet above the mouth of the shaft is a contact between the limestone and sandstone and the latter continues to the top of the bluff about 90 feet above.

The Buskett shaft was sunk several years ago and is now filled with water. For this reason I was unable to examine the rocks beneath the surface. Mr. Buskett furnished me with the following section, showing the rocks passed through and the thickness of each from the top to the bottom of the shaft:

No. 1. 3½ feet soil and clay with lead in clay.

No. 2. 1½ feet hard mottled flint.

No. 3. 3½ feet hard gray brittle limestone and flint nodules. Veins running north and south with lead and zinc.

No. 4. 3 feet bluish-gray sandstone. Some lead and zinc. Veins continue.

No. 5. 3½ feet gray siliceous limestone containing nodules of flint. Veins continue carrying barite and sphalerite.

No. 6. 2½ feet black and blue flint, with nodules of gray limestone. Considerable zinc sulphide and barite.

No. 7. 4 feet limestone, similar to No. 3, and barite, but no lead or zinc. Lower part merges into white flint.

No. 8. About 14 feet very white brittle flint for about 5 feet, then 3 or 4 feet containing nodules or yellowish gray limestone. The lower 6 or 7 feet contains clay openings, carrying barite and some zinc and lead.

When the three feet of bluish gray sandstone was encountered, the water came in very strong and increased until at a depth of 35 feet, it was impossible to handle it except with a large pump. Quite a number of pieces of rock containing zinc in the form of the sulphide and carbonate were scattered about the shaft. These were examined and found to resemble closely the deposits occurring on sec. 36, T. 37, R. 9 W. Apparently most of the mineral occurs in irregular cavities in the rock, although a rather clearly defined vein probably occurs near the surface where this shaft was sunk. The beds in which ore was encountered are probably the same as those occurring in the previously described locality.

The next property examined was the S. E. ¼ of the S. W. ¼ of sec. 34, T. 37, R. 9 W., on which a drill hole had been sunk to a depth of nearly 100 feet. This place is about 95 feet bove the level of the Little Piney River at Newburg. At a depth of 98 feet, it is reported that an opening carrying mineral was struck.

On the N. W. ¼ of the N. E. ¼ of sec. 6, T. 36, R. 9 W., outcrops were examined in the vicinity of three shafts, from all of which zinc ores have been taken. The different shafts were all sunk near the bottom of a small but somewhat precipitous ravine—two on the west and one on the east slope. The first shaft was sunk to a depth of 57 feet. Eighteen feet from the surface a drift was run west 40 feet. This shaft passed through about 17 feet of loose bouldery clay at the surface, the remainder being in solid rock. Occasional large bunches of crystalized galena were found in cavities in the rock through which the drift was made. This ledge is about 60 feet below the bottom of the sandstone formation and corresponds in position with the upper zinc-bearing limestone bed observed on sec. 36, T. 37, R. 9 W., and with the lowest bed in Buskett's shaft.

The second shaft, on the west side of the draw, had a depth of 20 feet, of which 16 feet are in talus, 2 feet in flint, and 2 feet in a clay seam. Both zinc and lead, in the form of the sulphide, are reported as occurring in a seam below the talus. The seam is said to trend in a northwest southeast direction.

The shaft on the east side of the draw has a depth of 20 feet. About 12 feet from the surface, a drift was run west at the same level as the drift in No. 1. Some zinc blende, zinc carbonate, and galena occur in this drift, partially filling the irregular openings in the limestone. In

this drift the lead and zinc occur together. Iron pyrites is associated, to a considerable extent, with all the lead and zinc ores taken from these shafts. Several drill holes have been sunk in the immediate vicinity of the shafts, and although it is reported that galena was found, it does not appear that any workable ore body was encountered.

After examining the above described land, I inspected the S. W. ¼ of the S. E. ¼ of sec. 33, T. 37, R. 9 W., where several small holes had been dug into the hillside. At a horizon about 55 or 60 feet below the sandstone some lead and zinc have been found, but not in any larger quantity than on the previously described property.

## Conclusions.

After considering carefully the conditions in this area and reflecting upon the developments which have been carried on, it is thought that one would be justified in saying that thus far the prospecting has not brought to light any very large body of ore. It appears that the strata which carry the lead and zinc ores, are open porous rocks, and the relation of the sandstone and limestone formations leads me to feel *that there may be in this region* places where open ground has been sufficiently extensive to account for the deposition of lead and zinc in workable quantities. If one could find a moderately wide zone of brecciation or a considerable thickness of open vesicular rock in which the lead and zinc ores could have been deposited, he would be thoroughly justified in continuing prospecting by drifting or sinking shafts.

It is believed, however, as a whole, that not enough attention has been given to a consideration of the conditions necessary for the occurrence of an ore body and that more money should be spent in work preliminary to the sinking of shafts and running of drifts than is being done at the present time. It would be to the advantage of any company or corporation to employ a competent economic or mining geologist, for two months, searching for the conditions which indicate favorable localities for prospecting before sinking shafts or running drifts. The expenditure of $300 or $400 in preliminary work would be money well expended.

If it is the intention to continue work on the shafts and drifts at any of the localities which were inspected, the showing made on sec. 36, T. 36, R. 9 W., is most favorable. In continuing work in this tunnel it would be wise to sink down on the brecciated or broken ground as closely as possible, with the hope that it may lead to more favorable conditions.

The fact that the shafts at the other localities examined were filled with water, making it impossible to thoroughly examine the properties,

impels me to refrain from making any comparisons. I believe that if it had been possible to have inspected the underground conditions at the three places, I would have found them to have differed very little.

I trust that in this report I have made myself clear, and should there be any questions or explanations necessary, I hope you will feel at liberty to call on me and I will make such explanations as I can. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF C. W. M. LOVE ET AL., KINGSTON, MO.

Petition to examine the following described lands, to wit: The principal part of the E, ½ S. E. ¼ sec. 19, 65 acres, and the south 61 acres of the W. ½ S. W. ¼ sec. 20, in T. 56, R. 27, owned by Algernon Wingate, E. ½ S. W. ¼ sec. 19, E ½ N. W. ¼ sec. 30, same township and range, owned by Hugh L. Baker and wife, N. ½ N. W. ¼ sec. 27, same township and ranges, owned by Joseph J. Boyd and wife, S. ½ N. W. ¼, N. E. ¼ and S. E. ¼, N. W. ¼ and S. E. ¼, N. E. ¼ and S. W. ¼ N. E. ¼, all in sec. 21, same township and range, owned by George J. Boyd, W. ½ S. E. ¼ and S. E. ¼ S. W. ¼ and 40 acres off of the south side S. ½ N. E. ¼ sec. 15, and N. W. ¼ N. E. ¼ sec. 22, same township and range, owned by W. H. Pearse and wife, S ½ S. W. ¼ and N. E. ¼ S. E. ¼ sec. 21, and S. ½ N. W. ¼ and N. ½ S. W. ¼ and N. ½ S. ½ S. W. ¼ and N. E. ¼ and S. W. ¼ of sec. 22, same township and range.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF KINGSTON.

In answer to your petition of October 28th, 1901, I spent April 15th and 16th in making an examination of the above described lands.

During the first day of this examination, I was accompanied by Mr. C. W. M. Love and Mr. Horace Johnston, and the second day by Mr. Horace Johnston. The purpose of this trip was to ascertain, if possible, whether the indications for petroleum and gas in this vicinity are sufficient to warrant deep drilling.

The rocks around Kingston belong to the Upper Carboniferous formation, many of the ridges exposing what is known as the Bethany limestone. Below the Bethany limestone, there is probably a thickness of about 400 feet of Upper Carboniferous rock, below which occurs Lower Carboniferous limestone.

There are certain conditions controlling the occurrence and distribution of oil and gas which must be looked for in an examination of property similarly located to that in the vicinity of Kingston.

First—One should determine, if possible, whether or not the conditions have been present for the production of oil or gas.

Second—Whether there is a reservoir for the storage of the oil or gas.

Third—Whether such reservoir is sealed by an overlying impervious strata of rocks through which the oil or gas cannot escape to the surface.

Any resemblance which there may be between the surface features of this region and that of the western Pennsylvania or Ohio oil and gas fields, is no justification for sinking a deep well with the expectation of finding oil. The escape of oil and gas from the rocks has some significance in a consideration of the probable occurrence of oil in any undeveloped territory, but it must be used in connection with other phenomena. In some cases it has a value in locating oil wells, but the assumption that the escape of gas and oil at the surface indicates the presence of great reservoirs underneath is often untrue and consequently misleading. It may be safely said that nine out of every ten surface indications of gas and oil represent no large accumulations beneath the surface.

The iridescent scum covering pools of stagnant water in marshes is often referred to as an indication of oil. This iridescent film is usually hydrous, iron oxide or bog iron ore. One must understand and recognize the fact that there are various kinds of surface indications, and that by far the larger portion of them do not indicate extensive reservoirs of either oil and gas.

During the two days which were spent in the vicinity of Kingston I found a bituminous limestone on the N. E. ¼ of the N. E.¼ and also on the S. ½ of the N. W. ¼ of sec. 34, T. 57, R. 27 W. This limestone occurs along a small branch and shows the presence of a black tar-like substance, which is probably asphalt. Undoubtedly the same indications of oil may be found at other places in this region. The bitumen has its source in the series of rocks in which it occurs, and is not derived from a deep seated reservoir.

From my examination of this region no conditions or surface indications were observed which would warrant the presumption that either oil or gas, in large quantities, will be found by deep drilling. It is possible that within a depth of 400 or 500 feet a small quantity of heavy ptroleum or asphalt might be obtained, but there are no indications at the surface which would warrant the presumption that petroleum or gas occur below that depth. Deep drilling which has been done in north central and northwestern Missouri gives no encouragement to deep drilling for petrloeum or gas in this part of the state.

I cannot consistently recommend the expenditure of money in this region in deep drilling for petroleum or gas. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF S. P. COLLINS, SR., ET AL., JERICO, MO.

Petition to examine the following described lands, to-wit:

N. W. Cor. sec. 3 to S. W. Cor. sec. 2, S. W. direction across N. E. Cor. 10, into sec. 11, T. 33, R. 28 W.

S. W. Cor. sec. 1, T. 33, R. 28, N. E. into sec. 36, T. 34, R. 28, and sec. 31, T. 34, R. 27; secs. 15 and 16, T. 34, R. 27 W., E ½ of N. E. ¼ sec. 6, T. 33, R. 28; secs. 21 and 28, T. 34, R. 27.

S. E. ¼ of S. W. ¼ sec. 20, T. 33, R. 28.

N. W. ¼ of S. E. ¼ secs. 29 and 30, T. 34, R. 28; sec. 17, T. 33, R. 27.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF JERICO.

In answer to a petition of 50 freeholders, residing in the vicinity of Jerico, I examined, in company with Mr. S. P. Collins, such parts of the above described lands as were thought to contain mineral.

This examination showed the occurrence of a brown iron ore between sections 26 and 27, T. 34, R. 28 W. Some bituminous limestone on sec. 14, T. 33, R. 28 W.; on sec. 36, T. 34, R. 28 W.; and on the S. W. ¼ of the N. E. ¼ of sec. 3. T. 33, R. 28 W. Spadalerite or zinc blende was found in two different shafts which have been sunk on the S ½ of sec. 16, T. 34, R. 27 W.

A large part of the region examined is underlain with Lower Carboniferous limestone. The ridges and hills, however, are capped with Lower Coal Measure shale and sandstone with which are interbedded thin layers of coal. The Lower Carboniferous limestone has, in some places, been weathered to such a degree as to be represented at the present time by a very fossiliferous brown residual chert. These residual cherts were examined in a great many places, but I was unable to find that they contained any ore in commercial quantities.

Bituminous limestone, such as is common to the Lower Coal Measures, occurs wherever the shales and sandstones or the upper beds of the Lower Carboniferous limestone are exposed. They have no special significance as to the probable occurrence of gas or petroleum in this region.

The iron ore, which is a brown hematite, occurs near the base of the Lower Coal Measure rocks and is pyritiferous. This ore has apparently resulted from an alteration of pyrite or marcasite. The iron ore examined contains too high a percentage of sulphur to be valuable.

The shafts sunk on sec. 16, T. 34, R. 27 W., have a depth of 70 and 216 feet, respectively. From both of these shafts pyrite, calcite and zinc blende were obtained. In the 70-foot shaft the zinc ore is reported to occur in thin seams and drusy cavities in the limestone. In the deep shaft it is reported that a 4-foot bed of limestone was encountered, which carried zinc blende, disseminated throughout its entire thickness.

It is very certain that zinc blende has been found in these shafts, but the quantity which occurs in the rocks has not been demonstrated.

Sufficient prospecting with the drill has not been done to prove this territory. The only way by which one can demonstrate the occurrence of a workable deposit of zinc ore in this area, is to drill or sink shafts into the underlying limestone. It is possible that paying quantities of zinc ore may be encountered, but it will require capital to prove the region. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITON OF M. E. FERGUSON ET AL., QUINCY, MO.

Petition to examine the following described lands, to-wit:

Secs. 18, 19, 20, 21, 28, 29, 30, 31, 32, 33 and 34, T. 38, R. 23 W., and sec. 3, T. 37, R. 23 W., all in Hickory county.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF QUINCY.

In a response to a petition, signed by yourself and others, for the examination of lands in the vicinity of Quincy, I visited that place March 21st and 22nd, and, in company with yourself and others, inspected the lands above described.

With the exception of the higher ridges and hills, the land in the vicinity of Quincy is underlain with Lower Carboniferous limestone. In a number of places on the higher ridges Lower Coal Measure sandstone was observed.

In places the limestone is bituminous, carrying small percentages of what may be asphalt. The richest deposits of bituminous limestone were found on the E. ½ of the N. E. ¼ sec. 30, T. 38, R. 23 W., at which place there is a seam apparently filled with asphalt. A pit has been dug on this vein, to a depth of about 8 feet. The vein is reported to be 18

inches thick, and to continue to an unknown depth. At the time that I made the inspection, a half barrel of asphalt stood near the pit, which, owing to the spring freshets, had caved in.

Bituminous limestone was also observde in the N. W. ¼ sec. 21, T. 30, R. W., and in the middle of the E. ½ of sec. 19, T. 38, R. 23 W.

On the S. W. ¼ S. E. ¼ sec. 24, T. 38, R. 23 W., a shaft has been sunk to a depth of about 48 feet, in search of zinc and lead ores. This shaft is on land owned by John Brown, who kindly furnished me with the following description of the rocks passed through.

10 to 12 feet talus.

6 feet shaley, sandy dolomite.

6 to 7 feet coarsely crystalline limestone, carrying some calcite.

6 feet dense coarse crystalline limestone, which has been brecciated and recemented with calcite.

20 inches blue shale, in which is disseminated considerable zinc blende.

10 to 11 feet limestone, chert and blue clay.

5 feet of uniformly fine grain limestone.

5 feet of rough, bouldery limestone, containing clay and pyrite.

The relations of the shale beds and limestone and the evidences of brecciation, combined with the occurrence of blende in the 20-inch layer of shale, leads me to consider this an excellent prospect. It is thought that the developments thus far carried on, give sufficient encouragement to warrant the expenditure of considerable money in continued explorations.

West of the shaft and in the bed of the creek there occurs considerable quantities of barite, disseminated through which are bunches of galena. This vein of barite seems to be of considerable width and moderately free from iron oxide. The occurrence of galena with the barite and the relation which the two bear to the country rock, makes this also a favorable point for prospecting. Without railroad facilities it may be impossible to sell the barite at a profit, but should railroad facilities be obtained, both the barite and lead, should they be found to occur in considerable quantities, will find a ready market.

With the exception of the asphalt occurring in the N. E. ¼ of sec. 30, T. 38, R. 23 W., and the lead and zinc in the localities above mentioned, no mineral prospects were found which would warrant the expenditure of any considerable money in development. Very respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF W. H. PAYNE ET AL., ALTON, MO.

Petition to examine the following described lands, to-wit:

S. W. ¼ sec. 9., S. W. ¼ sec. 3, S. W. ¼ sec. 17, S. W. ¼ sec. 18, W. ½ sec. 26, and W. ½ of sec. 28, all in T. 23, N., R. 2 W.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF ALTON.

The 18th of October, 1901, was devoted to an examination of mineral prospects in secs. 9, 17, 18, 28, 29, of T. 23 N., R. 2 W., 5th principal meridian.

The examination of these lands was made in company with Messrs. W. H. Payne and J. H. Harder. The first place examined was a ridge on which occurred boulders of ferruginous chert, mingled with ironstone. These iron-bearing cherts were observed 200 paces northeast on the same ridge and at other places in the vicinity. Near the base of the hill, on which they occur, but farther north, brown hematite was observed, mingled with chert and forming a brecciated mass. At this place a shallow hole had been dug, but no body of ore was revealed.

The next place visited was a shallow excavation in the limestone. Thin veins of what appeared to be calcite were observed cutting the rock, but there was no evidence of zinc or other mineral.

The next place visited was a shallow excavation in the side of a ravine. This opening showed a bed of white, yellow and purple clay, some of which had the appearance of chalk. This deposit is not considered evidence of the occurrence of either lead or zinc.

The sixth place visited was a shallow excavation, six or eight feet deep, showing brown hematite, mixed with chert. The surface of the ore is glazed in some places and frequently has an iridescent sheen. The quality of the hematite appears good, but the amount is apparently limited.

The seventh place visited was a small opening in a yellow limestone ledge near Mr. Harder's field. This limestone does not appear to contain any lead or zinc, but thin veins of calcite occur in many places.

The eighth place examined was an outcrop of limestone and chert at the head of a neighboring valley. The rock was apparently a cherty dolomite, containing layers or fragments of quartzitic rock. The stone is in places stained brown with iron oxide.

The ninth place examined was a shallow excavation, seven feet deep, showing a hard, flinty limestone, containing drusy cavities. An examination of samples from this place did not reveal any minerals of importance. Across the ravine from this place another excavation had been made in the limestone—an assay of which, by a man named Ogden, showed 80 cents per ton of gold.

A short distance east of this excavation was another from which a sample of limestone is said to have assayed $1.20 per ton.

Two shallow excavations have been made between secs. 29 and 30, but there was no mineral of value in sight.

The last place examined was on the east side of sec. 25, T. 23, R. 3. Here there was exposed a deposit of manganese of unknown quantity. Samples taken into the laboratory showed it to be very pure oxide of manganese.

## Conclusion

The inspection of these lands revealed considerable quantities of a good grade of brown hematite (iron ore) and evidence of manganese in the form of the oxide. Nowhere has development progressed sufficiently far to warrant a statement concerning the quantity available.

The iron seems to be very much scattered in small patches throughout this area. Only one deposit of manganese was seen, but the fact that it occurs in this region would justify one in making a diligent search for a workable deposit.

The rocks ore of such a nature and the region is so situated that the presumption is against the occurrence of gold and silver in workable quantities. On the other hand, the situation of the land is such that one might expect to find zinc ores in the district. However, none were found at the places inspected, as shown by analyses made in the Bureau laboratory. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

### PETITION OF JOHN B. KENNEDY ET AL., CAMERON, MO.

Petition to examine the following described lands, to-wit:

S. E. ¼ sec. 26, T. 58, R. 30 W., county of DeKalb.

The above petition was answered and the following report submitted to the interested parties:

### GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF CAMERON.

The surface rock of the land in the area above described is limestone. The streams have cut channels through this limestone exposing

clay, clay shale, carbonaceous shale and a thin seam of coal. The coal seam is about 2½ inches thick and at one place dips about 12 degrees N. W. Underneath the coal is a thickness of 2½ feet of fire clay, which passes into shale, carrying many nodules of flint and limestone.

It appears from the examination made, that this coal seam is the marginal portion of what may be a larger deposit to the northwest. Whether a workable seam would be found at a shallow depth below the creek bottom can only be demonstrated by drilling or sinking a shaft forty to fifty feet. The presumption is somewhat against the possibility of striking a workable seam at this depth.

If coal is not met with at the depth above mentioned, I would not expect it to be encountered above a depth of 275 or 300 feet. The quantity of coal to be found at this depth is not known. One would need simply to speculate on the favorable indications.

Should you decide to sink a shaft or drill a hole to the depth of forty or more feet, I trust you will give me an opportunity to examine the material passed through. Very respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF J. C. CRANE ET AL., EXETER, MO.

Petition to examine the following described lands, to-wit:

Sections west of the city, in T. 23, Rs. 28 and 29 W., in the county of Barry.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF EXETER.

In compliance of a petition of 50 freeholders of Barry county, Mo., to inspect land in the vicinity of Exeter, especially the E. ½ of the S. E. ¼ of the S. W. ¼ of sec. 21, T. 23, R. 8, I examined said property, in company with J. O. Boucher, B. F. Northcut and J. C. Crane, on the 16th day of October, 1901.

My inspection included the examination of a shaft that had been sunk to a depth of 34 or 35 feet through clay and sandstone into about 10 feet of shale. The lower four feet of the shale bed was bituminous and contained thin seams of coal. The shale beds contain nodules of iron pyrites, known as sulphide of iron. At the bottom of the shaft there occurred a bed of sandstone, having a dark bituminous appearance, similar to certain beds encountered above the shale.

My inspection also included an examination of a small stream and

stagnant pools of water a short distance west of the shaft. The water in the stagnant pools was covered with a scum and contained a soft yellow mass of iron oxide.

The inspection further included an examination of water taken from a well about two miles northeast of where the shaft had been sunk. The water examined gave off no odor and there was no evidence of oil or gas.

The shale occurring in the shaft gives no evidence of gas or oil. The greasy appearance on the stagnant pools of water is due to the extraction of iron oxide from the water, and is no evidence of oil.

From the above I would conclude that there is very little reason for believing that oil or gas occurs below a depth of 300 feet on the property examined. Neither is it probable that oil or gas will be found in any considerable quantity within 300 feet of the surface.

The presumption is also against the probability of obtaining coal at a greater depth than 300 feet. Coal may be found inside of this depth, but whether or not it occurs in workable quantity can only be demonstrated by drilling or continuing the shaft to a greater depth. Respectfully submitted.

E. R. BUCKLEY,
State Geologist.

The petition of J. A. G. Reynolds and 50 freeholders of Ava, Missouri, was answered and reported upon by the acting State Geologist. This petition called for the examination of the following described lands, to-wit:

The S. W. ¼ of the N. E. ¼, and the S. E. ¼ of the N. W. ¼, sec. 13, T. 25, R. 16 W., in the county of Douglas.

A petition from G. C. Henson, Sr., and 50 freeholders of Holt, Missouri, for the examination of lands in the vicinity of that city was answered and reported on by the acting State Geologist prior to the present administration.

A petition of J. S. Carr and 50 freeholders of Center, Missouri, was found among the papers of the Bureau after the change of administration. This petition gives no description of the lands to be examined and was not legally certified to.

Besides the above petitions, a number of requests for the examination of mineral lands, which were not accompanied by petitions, have been answered and reported on. All of these requests have been answered in person by the State Geologist. Among the places visited for the purpose of making these examinations may be mentioned Fordland, Braymer, Creighton, Edgar Springs, Richmond, Joplin, St. Clair, Palmer, Aurora and Winston.

INTERIOR VIEW OF THE LIBRARY.

## DISCUSSION OF THE MINERAL RESOURCES.

### Asphalt and Asphalt Rock.

Thus far no workable deposit of asphalt has been found in Missouri. Thin seams or pockets in the Burlington limestone, filled with asphalt, are not uncommon, but nowhere does the so-called "tar" occur in sufficient quantity to warrant exploitation.

Asphaltic sandstone and limestone are both abundant through the west central part of the state. At one place, Liberal, the asphaltic sandstone is being quarried and sold for curbing and sidewalk purposes. In some places the stone appears to contain a sufficiently high percentage of bitumen to make it suitable for rock asphalt pavements, but in many places the percentage is much too low.

It is thought that these deposits, which are scattered over a considerable area in the western part of the state, give sufficient probability of value to warrant an examination by the Bureau.

### Barite.

Barite, or barium sulphate, on account of its high specific gravity, is commonly known as heavy spar. In commercial quantities, it occurs mainly in the central and southeastern parts of Missouri, and is usually associated with the lead and zinc ores. The output for 1901, according to the report of the State Lead and Zinc Mine Inspector, was 32,388 tons, valued at about $3.22 a ton. The principal part of the output comes from Washington county.

The value of some of the zinc and lead mines is more or less impaired by the presence of barite, which constitutes the gangue mineral. An economical method of separating these minerals, when they occur together, would increase the output in the southeastern region. In the Franklin and Washington county mines, barite is the common gangue mineral, as far as the veins have, up to the present time, been exploited. The value of many of the mines in this county would be materially increased if it were known that the barite decreased with depth. As far as our examinations have gone, it is believed that this may be the condition in some instances, but in others the evidence of a generation of barite older than the zinc blende is evidence that it may continue with the zinc ore to the bottom of the vein. Further, there is evidence in this area of contemporaneous deposition of the barite and zinc blende. Before this question can be settled with any degree of certainty, a careful examination must be made of the deposits throughout the entire area.

## Cement.

Cement is composed of a mixture of alumina, silica, and calcium carbonate in more or less definite proportions depending upon the kind of cement manufactured. Calcium carbonate is the most abundant constituent and, as used, occurs in the form of limestone or marl. Alumina and silica are usually supplied by clay or shale, of which they comprise the main constituents. These three necessary ingredients, calcium carbonate, alumina and silica, frequently occur in nature in approximately the correct proportions for cement, constituting a shaley limestone. Where such a combination occurs in a stone it is commonly known as hydraulic limestone, and from it natural cement may be manufactured.

Scientific investigations have shown that the best cement is obtained from a mixture of definite proportions of alumina, silica and calcium carbonate. The correct proportions of the constituents are obtained by mixing clay or shale with limestone or marl of known chemical composition. Cement which is made from such a combination is called Portland.

The following tables give the composition of a few of the typical limestones, marls, clays and shales used in the manufacture of Portland cement.:

ANALYSES OF TYPICAL LIMESTONES AND MARLS.*

| | Chalk England (Reed). | Cement rock, LaSalle, Ill. | Cement rock, Siegfried, Pa. | Marl, Sandusky, Ohio. | Marl, Syracuse, Ind. |
|---|---|---|---|---|---|
| Calcium carbonate.... | 98.57 | 88.16 | 68.91 | 91.77 | 88.49 |
| Magnesium carbonate | 0.38 | 1.78 | 4.28 | 0.53 | 2.71 |
| Calcium sulphate..... | ..... | ..... | ..... | 3.19 | 1.58 |
| Silica..... | 0.64 | 8.20 | 17.32 | 0.22 | 1.78 |
| Alumina..... | 0.16 | 1.00 | 7.07 | 1.22 | 0.91 |
| Iron oxide..... | 0.08 | 0.30 | 2.04 | 0.40 | 0.30 |

*The Cement Industry, pages 12 and 13.

ANALYSES OF TYPICAL CLAYS.*

| | Medway, Eng. | Harper, O. | Sandusky, O. | LaSalle, Ill. |
|---|---|---|---|---|
| Silica..... | 70.56 | 51.50 | 65.41 | 54.30 |
| Alumina..... | 14.52 | 13.23 | 16.54 | 19.33 |
| Iron Oxide..... | 3.06 | 3.30 | 6.06 | 5.57 |
| Lime..... | 4.43 | 11.52 | 2.22 | 3.29 |
| Magnesia..... | ..... | 3.45 | 1.88 | 2.57 |
| Carbonic acid..... | 3.48 | 12 85 | ..... | ..... |
| Alkalies..... | 3.95 | ..... | ..... | ..... |

*The Cement Industry, pp. 12 and 13.

Missouri is supplied with unlimited deposits of clay, shale and limestone which together contain the three essential constituents for the manufacture of Portland cement. Two factories—the first in the state—have been erected in Missouri this year for the manufacture of Portland cement. One of the factories, located at Hannibal, and owned by the Atlas Cement Company, when completed, will have a capacity of 7,000 barrels a day. The other, located at Prospect Hill, just north of St. Louis, owned by the St. Louis Portland Cement Company, has a capacity of 1,500 barrels a day. This factory began operations about the first of November of this year.

The Hannibal, Hudson River and Hamilton formations, outcropping in many places throughout the eastern portion of the state, constitute an inexhaustible supply of shale suitable in many places to supply the necessary silica and alumina for the cement. The pure limestones of the Burlington, Lithographic and Trenton formations constitute an abundant supply of calcium carbonate for the remaining constituent.

It is thought that within a few years many more Portland cement factories will be erected in different parts of the state.

**Clay Products.**

There are over three hundred and fifty clay manufactories in Missouri, with a total output in 1901 of four and a half millions of dollars. The rapidly decreasing supply of lumber is compelling builders to look to brick, terra cotta and cement as the building material of the future. As the demand for constructional materials increases so will the search for suitable clays for the manufacture of these products increase. The growth of the clay industry in Missouri during the next decade will probably outstrip the development of any of the other mining resources, except, perhaps, the mining of lead and zinc and the manufacture of Portland cement.

The search for clay deposits suitable for the manufacture of the multitude of clay products now in use is constantly going on. Inquiries are constantly coming to this office asking for the location of clay deposits suitable for the manufacture of different kinds of clay wares. New deposits are being uncovered each month and samples are received for examination.

The richness and variety of the clays in Missouri are surpassed by few, if any, of the states in the Union. Their nearness to the coal mines, the extensive markets for clay wares at home and abroad and the excellent railroad facilities contribute to give this industry an advantage possessed by few of the neighboring states.

**Coal.**

The report of Mr. Charles Evans, State Coal Mine Inspector, for the year 1901 shows the largest coal production in the history of the state, amounting to 3,813,527 tons, valued at $4,716,331 at the mines. The number of mines and strip pits operated is reported to be 368. During the year new mines were opened by twenty-six different companies.

The work which the Bureau has been carrying on in Central Missouri has included an examination of several deposits of coal in Miller, Morgan and Moniteau counties. The coal in these pockets is worked by the strip pit method. These deposits afford a valuable supply of fuel for local consumption. However, the quantity of coal in any of the pockets examined is not sufficient to warrant the installation of modern machinery.

There are undoubtedly large bodies of coal in the northern and northwestern parts of the state which have not yet been discovered. It is thought that a careful study of the formations in these parts of the state might assist in extending the known extent of the coal fields.

**Cobalt—See Nickle.**

**Copper.**

As yet there are no producing copper mines in Missouri. From Dent, Crawford, Phelps, Shannon and other southeastern counties, reports have been received announcing the discovery of copper ores, but in no instance has exploration revealed a sufficient quantity of ore to insure profitable development. From one locality a car load of ore was shipped to a St. Louis furnace with very gratifying results. The only point in question is the quantity available. The ore is found mainly in the form of a carbonate or sulphide. The Bureau has made no examination of the deposits referred to and can give no idea of their probable extent.

**Gas and Oil.**

The Beaumont, Texas, oil excitement has naturally turned the attention of many people in Missouri to the possibility of finding these products in this state. A number of companies have been organized in the northern and western parts of the state for the purpose of prospecting for oil. As a result of these organizations a number of deep wells have been bored, few of which have given any evidence of oil or gas in commercial quantities. At Belton, near the Missouri-Kansas boundary, there are several wells which are producing a few barrels of oil a day. Outside of these, none of the wells are of commercial importance.

The oil excitement in Texas, Louisiana, Colorado, and elsewhere, combined with the fact that oil occurs, in small quantities, in some portions of the Carboniferous formation in Missouri, has interested many of our citizens to the extent of either writing to this office for general information on the occurrence of gas and petroleum or requesting the State Geologist to make an examination of lands in which they were interested. Individuals, oil companies, business men's clubs and city improvement organizations have all sought the service and advice of the State Geologist in prospecting for petroleum and gas.

Where it has been possible, I have visited the localities from which these requests came and have made such explanations and suggestions as the limitations of my office would permit. In other instances I have submitted written reports on the properties examined, giving all the evidence found in support of the opinion expressed.

A number of erroneous impressions prevail throughout the state as to the origin of petroleum and gas, which, if explained, might serve to direct the attention of the prospector into fields which give greater promise of returns.

One of the common beliefs is that there is a reservoir of petroleum under the Gulf of Mexico and that the wells at Beaumont draw their oil from this reservoir. This being the supposition, it is thought that a well need only be sunk to sea level in Missouri, in order to tap this great underlying reservoir of oil. Others believe that the so-called Trenton limestone is the great oil and gas bearing horizon of the continent, and that if this can be reached, unlimited supplies of oil and gas will be obtained. A seepage of oil from the rocks at the surface is evidence to others that petroleum occurs in considerable quantities deep within the earth. The occurrence of salt water and sulphur has also been pointed to as evidence of the occurrence of petroleum. It will be shown in the following pages that those who believe the above are often in error.

It is true that most of the petroleum and gas which is found in this country is brought from depths which are below sea level. At Tiffin, Ohio, gas is obtained at a depth of 1,500 feet, which is 747 feet below sea level; at St. Henry's, Ohio, gas occurs at a depth of 1,156 feet, which is 200 feet below sea level; at Muncie, Ind., gas occurs at a depth of 900 feet, which is just sea level. The Trenton limestone is a gas and oil reservoir in Ohio and Indiana. Seepage of oil in a certain part of the country has frequently lead to the discovery of oil in other parts. Salt water very frequently occurs with petroleum and gas, but they are not always the accompaniment of one another. Sulphur is also frequently associated with the deposit of petroleum, but this, in turn, is not always an evidence of the occurrence of oil. None of these in itself,

however, can be taken as conclusive evidence of the occurrence of petroleum or gas in commercial quantities.

A very common error, which is made in Missouri, is the mistaking of an iridescent scum which often floats on the surface of stagnant pools, as a seepage of petroleum. This scum, which occurs very commonly in swamps, is the accompaniment of flocculent deposits of bog iron ore. On several occasions during the last year I have been called to examine certain evidences of petroleum which turned out to be nothing more than the iridescent scum referred to above.

In many places throughout the western and northwestern parts of the state, there are numerous outcrops of bituminous shales, sandstones and limestones which have been considered by many people to be very strong evidence of the occurrence of petroleum at greater depths. Provided the conditions for concentration and storage are also present, these bituminous strata should be given consideration, but otherwise they have little significance.

There is an entire lack of knowledge on the part of the public, first, as to what phenomena may be considered evidence of the occurrence of petroleum, and, second, as to what the strategraphic and structural conditions in Missouri are which bear upon the question of petroleum and gas in this state. In the following pages will be found a resume of the manner of occurrence of oil and gas in the more important fields of the United States. From this resume it is hoped that the reader will be able to correct some of the current fallacies connected with the occurrence of petroleum and gas. Following this resume, a statement will be made as to the origin and methods of occurrence of oil and gas in different parts of the United States. I will also attempt to show how far the geologist can be of assistance to the gas and oil prospector.

Pennsylvania—The so-called Pennsylvania oil field comprises portions of Pennsylvania, New York, West Virginia and Ohio. It consists of sixty or seventy, more or less, isolated areas, commonly known as oil pools. The oil is contained in sandstone beds of Devonian and Carboniferous ages. These sandstone horizons occur at different depths from the surface, depending upon the portion of the mountainous regions in which they occur. There is a thickness of about 350 feet of strata containing three somewhat distinct horizons of sandstone. In some places only one of these horizons is present, while in other cases all three occur. Where all three are found, only the lowest is oil bearing. The two upper sometimes carry gas. The sand varies in texture from that which is very fine grained to that which is conglomeratic. The conglomeratic usually occurs at the lowest horizon.

Ohio-Indiana.—The Ohio-Indiana gas and oil fields consists of three

or four irregular areas in south-central Indiana and northeastern Ohio. The gas and oil occur in the limestone of the Trenton formation. The rock is oil and gas bearing only in limited areas, apparently depending upon the porosity of the rock. Where the oil and gas occur the rock is a porous, magnesian limestone. Outside of these areas the rock is non-magnesian and not porous. At Findley, Ohio, the gas bearing limestone was encountered at a depth of 1,100 feet.

Kentucky.—In Kentucky, as in Pennsylvania, the oil and gas strata occur in sub-Carboniferous and Devonian shales. Neither oil nor gas are found in the Trenton of this area. One of the horizons at which oil is found occurs 50 feet below the bottom of the Devonian, probably in the Clinton horizon. The other horizon is 150 feet above the upper surface of the Devonian.

Texas.—Texas has two important oil and gas fields, the Corsicana and the Beaumont. In the Corsicana field the oil is found in a highly silicious gray slate of Cretacious age. This horizon occurs at a depth of 1,050 feet. The oil of the Beaumont field is derived from sands which are probably of Pliocene age. The sands occur at a depth of from 900 to 1,000 feet. There appears to be no connection either in the age or the character of oil, between the Corsicana and Beaumont fields.

California.—In California the oil bearing rocks are mainly sandstone of Miocene or Pliocene age. Natural gas has been found in Cretaceous rocks in Caloosa county and in the Quarternary formations of San Joaquin county.

European Countries.—In the Galicia fields of Austria-Hungary, the oil bearing rocks range in age from Cretaceous to Miocene. The Roumanian oil is said to occur in rocks of the same age. The oil bearing rocks of the Baku fields in Russia are Lower Miocene.

Resume.—From this brief summary it will be noted that oil and gas occur alike in mountainous, hilly and prairie regions; that they occur in rocks of different ages, from Devonian to Quarternary time; and that they are contained in limestones and shales as well as sandstones. The kind and age of the rock do not seem to control the formation and storage of petroleum and gas in the formations younger than Cambrian. Other conditions besides these must be known before one can account for the present distribution of the oil and gas fields of the United States.

## CONDITIONS AFFECTING AND CONTROLLING THE OCCURRENCE OF PETROLEUM AND GAS.

As far as the records show, petroleum and gas, in commercial quantities, have not been found in rocks older than Silurian. The Trenton limestone of the Indiana-Ohio fields constitute the oldest rocks in which

any commercial quantities of oil and gas are found. This occurrence is rather exceptional. Nearly all of the other petroleum or gas bearing strata are found in the Devonian or younger formations. This may be due to the fact that materials for the production of petroleum and gas were not present in the older formations or perhaps to the absence of conditions for the storage and retention of the oil and gas when once produced.

### *Origin of Petroleum.*

It is generally conceded at present that both oil and gas are produced by the decomposition and distillation of organic matter laid down with the sediments which compose the rocks. It is thought that the oil and gas has in most cases resulted from the decomposition of organic matter, both vegetable and animal, deposited with the rock from which the gas and oil are now derived.

The oil and gas of the Pennsylvania field has undoubtedly been in a large measure derived from the shales associated with the sandstone strata. The gas and oil of the Indiana-Ohio field is thought to have resulted from the decomposition of the organic remains of which the limestone is largely composed.

Edward Orton, Sr., in his report on the occurrence of petroleum, natural gas and asphalt rock in western Kentucky, concludes, after a discussion of the various oil fields:

"1st, petroleum is derived from organic matter; 2d, petroleum of the Pennsylvania type is derived from organic matter of the bituminous shales and is probably of vegetable origin; 3d, petroleum of the Canada type is derived from limestones and is probably of animal origin; 4th, petroleum has been produced at normal rock temperature—(in American fields), and is not a production of destructive distillation of bituminous shales; 5th, the stock of petroleum in the rocks is already practically completed."

### *The Oil Rocks.*

Any porous rock, which is overlain by an impervious strata and confined either by the limbs of an anticlinal fold or by changes in the texture and composition of the rock through which it becomes impervious on all sides, may constitute a reservoir for oil or gas. The porosity of sandstone and limestone and sometimes shales is sufficient to provide for the storage of all of the oil and gas which is produced from the interior of the earth. If a limestone or sandstone formation contains on an average of one-tenth of one per cent of petroleum and has a thickness of 500 feet, it will have a capacity of 2,500,000 barrels of petroleum to

the square mile. Edward Orton, in the report above referred to, estimated that a production from the oil field of Pennsylvania and New York of 300,000,000 barrels of oil would require only 125 square miles from the sub-Carboniferous limestone alone.

There is no difficulty in finding space in a rock sufficient to accommodate all of the oil and gas which can be distilled from the organic contents. Sandstone, which is the rock in which oil and gas are most commonly found, may be fine grained, coarse grained or even conglomeratic. The third oil sand of the Venango field is conglomeratic. It has been found that usually the coarse sands contain the largest quantities of oil, some of the conglomerates running as high as 10 per cent. These sandstones may be of uniform thickness over large areas, but frequently they occur as irregular lenses enclosed with shale or slate. Usually the sandstone horizons are of irregular thickness, varying from a few to several hundred feet.

Sandstones are usually more porous than either limestone or shale. Actual measurements have shown that ordinary sandstones contain from 10 to 29 per cent of pore space, providing an abundant reservoir for either oil or gas. Limestone constitutes the great reservoir for the oil and gas of the Ohio-Indiana field. This limestone is of Trenton age and in places is so porous, foot for foot, that it has been estimated to have a greater storage capacity than the sandstone of Pennsylvania. The Trenton limestone in this field is not everywhere porous. Apparently the solution cavities have been formed only where it is dolomitic. Where not dolomitic, the stone is compact and contains very little pore space for the retention or storage of either oil or gas. There are only limited areas of Trenton limestone in this field that are oil or gas bearing.

In western Kentucky the oil bearing rock is a shale. There are many places where small accumulations of oil are found in shales, but this is the only one where the oil is sufficiently concentrated to be of importance. The petroleum in these shales must be carried in the open joints and not in pores or cavities in the rock.

Nowhere is it necessary to suppose the occurrence of caverns or subterranean chambers to account for the storage of gas and oil within the earth.

### *The Impervious Cover.*

After conditions for the production and storage of petroleum and gas have been fulfilled, provisions must be made for its retention. Oil and gas are both lighter than water and if an avenue of communication remains between the reservoir and the surface of the earth, the oil will cer-

tainly be brought to the top and there oxidized. So it has been found, that, wherever a reservoir occurs in which oil or gas are stored, this porous horizon is overlain with a fine grained, impervious shale or limestone which prevents the escape of the oil and gas. In any case this cap rock must be unbroken, else we need not look for oil or gas. Apparently in eastern and central Pennsylvania the breaking of the flexed strata has resulted in the dessication or evaporation of the petroleum.

*Flexures.*

The three conditions previously enumerated—a source for the petroleum and gas; a reservoir for its storage; a cap rock to prevent its escape above; may all be present in a given region, and yet no oil or gas be found. The reservoir must not only be capped with an impervious strata, but it must also be enclosed from east to west and from north to south, so that the oil and gas will be removed from the general circulation of underground water. A flexing of this strata, by which long canoe or dome shaped elevations are produced, provides the conditions desired for the retention of the oil and gas. Such flexures in western Pennsylvania and eastern Ohio constitute perfect reservoirs for the storage and retention of oil and gas. A modification of this so-called anticlinal structure is found in the terrace structure of the Indiana-Ohio field. Here the productive arch or anticlinal is low and flat, though similar in all respects to the sharper folds of the Pennsylvania fields. Edward Orton, in his report on the "Petroleum, Natural Gas and Asphalt Rock in Western Kentucky," explains the Terrace structure in the following words:

"In a region of uniform depth, for example, the upheaving force may go no further than to arrest the steady descent of the strata. If the whole had lain horizontal at the beginning, the force exerted would have been sufficient to bend them into a low arch; but, as the strata were descending, the force has all been used in arresting the descent and bringing the beds up to an approximately horizontal position for a small space. This peculiar structure has been designated arrested anticlinals."

The structure of the formation at Beaumont, at Corsicana and other fields, has not yet been worked out. W. B. Phillips, in a report of the Texas Mineral Survey on petroleum, states that there may be a flexure at Beaumont, the apex of which is at Spindletop.

In general we may recognize two classes of gas and oil fields: one, found upon the summits of low anticlinals, as illustrated in western Pennsylvania, and the other occupying the terraces such as occur in the Trenton limestone in northwestern Ohio and central Indiana. These

structures are vitally important for the retention of petroleum and gas in any region where the conditions are favorable to its production and storage.

In general, the man who prospects for oil must first know that the conditions for the production of petroleum have been present; second, that a reservoir in the shape of porous limestone, sandstone or shale occurs above the source of the petroleum or gas; third, that the reservoir is sealed above by an impervious formation of shale; and, fourth, that the strata have been so flexed as to form a dome or terrace in which the oil and gas are removed from the path of circulating waters.

*Relation to Salt and Fresh Waters and Sulphur.*

In many instances sulphur is found associated with the rock in which petroleum and gas is found. In the limestone capping the oil sand of Beaumont, native sulphur occurs. It has also been observed associated with the petroleum deposits in other parts of the country. In fact, the value of petroleum depends more or less upon the amount of the sulphur that it contains.

Salt is very often found with deposits of petroleum. The petroleum is lighter than salt water and naturally occurs on top of it. Fresh water is lighter than salt water and is frequently found between the petroleum and salt water. Where gas is found it precedes both the petroleum and water. The usual order in which these products occur is as follows: gas, petroleum, fresh water, salt water. It is known that in the Corsicana field below the oil horizon the sand is filled with salt water. The separation of the water, oil and gas is accomplished by gravitative forces. Edward Orton has very aptly said that "Where both oil and gas are found in a single field the first sign of approaching failure will be the invasion of the gas rock by oil or of the oil rock by salt water." Salt water follows the gas directly, however, in a great many fields without the intervention of an oil horizon.

*Pressure.*

The so-called "spouting" of oil wells, which gives them the name of "Gushers," is attributable to hydrostatic pressure. The flow of gas may be due in part to relief from compressed conditions in which the gas is confined in the reservoir. There is little plausibility, however, in the theory which attempts to account for this phenomena through the pressure exerted by the weight of the super-incumbent rocks. "The flow of gas and oil depends upon the pressure of a water column or in other words, every flowing gas or oil well is in reality an artesian well. With

the principle involved in an ordinary artesian well all persons are familiar and it will therefore be easy for such to extend the application of these wells to the cases now under consideration." (Orton.)

### GEOLOGICAL AID TO OIL AND GAS PROSPECTORS.

The geological indications that can be made of service in locating oil or gas wells are: 1st, the succession of strata at any particular place, which includes such a knowledge of the rocks that one can state the probability of a reservoir occurring at proper depths; 2nd, the structure and arrangement of the beds from which one may determine favorable or unfavorable conditions for the retention of oil or gas.

A geologist should first ascertain whether conditions have been present for the formation of petroleum and gas; second, whether the successions of strata provide a suitable reservoir for storage; and, third, whether the structure of the beds are such as to provide suitable conditions for the retention of the oil and gas which may have been formed.

Seepages of oil and the presence of bituminous matter in shales, sandstones and limestones, are evidence that conditions existed somewhere for the production of petroleum. An examination of the rocks in which this bitumen occurs will probably furnish evidence as to the source of these products. A knowledge of whether conditions existed for the storage and retention of the oil and gas can only be obtained through a study of the geological conditions in all parts of the state in which the investigation is made.

In searching for domes, anticlinals and terraces, one must constantly bear in mind that each of these gradually die out with depth. A flexure of considerable amplitude, but of no great length or width, frequently dies out within a few hundred feet of the surface. After considering the depth to which an anticlinal or terrace continues, we must assure ourselves that the horizon included within this flexure is suitable for the storage of the petroleum and gas.

### CONDITIONS IN MISSOURI.

The northern and western parts of Missouri are underlain at the surface with Upper and Lower Carboniferous rocks. The Lower Carboniferous rocks consist mainly of limestone, in which occur only occasional small pockets of bituminous matter in the form of asphalt. This heavy tar or asphalt originally had its home in the bituminous shales and sandstones in the form of petroleum. It now constitutes the residuum from the distillation of that petroleum which was oxidized by being brought into the zone of weathering. The tar residuum has slowly crept downward into the cracks of the limestone, where it is now found

filling crevices and pockets. Underneath the Carboniferous formation occurs a thick series of limestones and sandstones, none of which, as far as our observations go, present conditions favorable for the production or petroleum or for the retention of it should it have been formed in this horizon. The alternate series of dolomite and sandstone beds which are older than the Carboniferous rocks give no evidence of petroliferous deposits of any character.

The Upper Carboniferous rocks consisting of Coal Measure shales and sandstones outcrop throughout the northern and western portion of the state. The vegetable remains occurring in these beds are sufficient to account for the formation of petroleum and gas, while the sandstone horizons are sufficiently porous to provide a uitable reservoir for their storage. In some places in the northern and western parts of the state the rocks have been more or less flexed and towards the Kansas border in the west central part of the state, there is a probability of finding oil and gas in limited quantities. In some parts of the Upper Carboniferous formation, the bitumen occurs in the form of an asphalt. A considerable portion of the oils originally contained in the rocks have been brought to the surface through joints in the rock and here oxidized by the atmosphere. The lighter oils have been evaporated and the heavy residuum remains as a sticky mass in the pores of the rock.

The oil and asphalt which occur in this region has been derived from the Upper Carboniferous shales and are no evidence in themselves that larger deposits will be encountered below the Upper Carboniferous formations.

**Gold and Silver.**

As usual, a great many specimens have been assayed by the Bureau for gold and silver, but none were found to contain either of these metals in a measurable quantity. Some of the galena of the southeastern district is known to be argentiferous, but nowhere is either silver or gold known to occur in sufficient quantity to make profitable mining.

**Iron.**

Missouri is still a producer of iron ore, most of which is sold to furnaces within the state. The development of the enormously rich iron ore bodies of the Lake Superior region has in a large measure caused the Missouri iron banks to be abandoned. In some cases it was found that as the ore was mined to moderate depths, it was in part replaced by iron sulphide. Apparently the ore in some of the more important banks is an alteration product of iron sulphide. It is probable that with any increase in the demand for iron many of the old banks will be reopened.

The iron ore mined in 1901 came from Crawford, Dent, Franklin, Iron, Oregon, Phelps and St. Francois counties, and amounted in all to 140,280 tons.

**Granite.**

In the southwestern part of the state, in Iron and Madison counties, there are some of the most extensive deposits of red granite in the Mississippi Valley. The granite occurs in masses which constitute small hills and can be obtained in pieces of any desired dimensions. The stone is not only suitable for monuments and road materials, but it is unsurpassed for building constructions. It is hard, strong and durable, and takes a polish which is surpassed by very few red granites in brilliancy or luster. The granite when crushed makes an excellent product for macadam pavements or concrete walks. The curbing and paving blocks which are manufactured from the stone, although more costly to manufacture, are superior in strength and durability to the Georgia and similar gnessoid granites.

The output from the quarries in this district according to the United States statistical register for 1899, sold for $151,688, which is the maximum output since 1893.

**Lead and Zinc.**

The year 1901 showed an output of 109,376 tons of lead compared with 78,538 tons for 1900, an increase of 30,838 tons. The output sold for $4,865,518 in 1901, against $3,762,202 in 1900, an increase of $1,139,316. The average price of the lead ore was $44.30 per ton in 1901 against $47.47 in 1900.

The output of zinc for 1901 was 224,073 tons against 186,296 tons for 1900. Of this only 16,839 tons was silicate. The average selling price of the ore was $23.70 per ton in 1901 against $31.76 for 1900.* Nearly nine hundred mines were in operation in 1901 and the total output of lead and zinc amounted to $10,158,266.

The increased production for 1901 is due to a healthy and normal development of lead and zinc properties in different parts of the State. It can no longer be said that the southeastern and southwestern districts are the only lead and zinc producing sections. The south central and north central sections of the Ozark region south of the river, are both producing ore for the market. The production is unquestionably small when compared with the output of Jasper and St. Francois counties, but the districts are young and little is known as to their future possi-

*These figures are taken from the report of the State Lead and Zinc Mine Inspector, for 1901.

bilities. This year has witnessed the opening of two productive mines near Fortuna in Moniteau county, which has resulted in very general prospecting throughout the region. At West Plains, Howell county, a zinc oxide plant was erected this last year, the supply of zinc carbonate being drawn largely from Oregon and Howell counties.

The last year has witnessed the opening of several new mines in the southeastern district, but prospecting has been almost at a stand still. A number of new and old mines have been opened in the southwestern district, as a result of the advance in the price of zinc ore. Mining in both the southeast and southwest districts is on a scientific basis and prospecting is no longer carried on by "cut and try" methods.

The United States Geological Survey has three men in the Southwestern district engaged in a study of the ore deposits for the purpose of publishing a complete detailed report on the region. This work is receiving the hearty support and encouragement of the mining interests of that region. The importance of this work in the systematic development of the ore bodies and the opening up of new ones can only be appreciated by one who has been engaged in mining operations in this very complex region.

The mining interests of the southeastern, or disseminated lead region are expecting that the State Bureau will begin a similar line of investigation in that district during the coming season. The people of these districts contribute very largely to the wealth of the State and should receive any assistance which it is in the power of the Bureau to render. It is hoped that before another biennial period, the Bureau will have well under way a report on the Disseminated Lead district. Such a report will not only aid in developing the present mines, but should assist the prospector in extending the district into other undeveloped sectons.

**Lime.**

Although to some extent displaced by cement, quick lime is still produced in large quantities in Missouri. The limestone of the Upper Burlington formation is unsurpassed for the manufacture of white quick lime by any formation in the country. The Trenton limestone in the eastern part of the State is also a good lime producer. The dolomitic limestone of the Cambro-Silurian formations of the Ozark region has been used locally for the manufacture of quick lime, but nowhere has it been produced for shipping. The Burlington limestone makes a quick setting lime, while that produced from the Cambro-Silurian dolomites is slow setting. The former is usually very white, while the latter is gray.

The value of the output of quick lime in 1899 was $383,543, according to the statistical register of the United States Geological Survey.

**Mineral Paints.**

Not considering lead, zinc and barite, Missouri produces small quantities of the other common Mineral Paint, products among which are, Ocher, Umber, Sienna and Metallic paint pigments. The total output probably does not exceed six or eight hundred short tons per year valued at about $10,000.

**Mineral Waters.**

In 1901, thirteen mineral springs were reported to the U. S. Geological Survey as marketing mineral waters. During that year 784,330 gallons were sold for $147,715. Missouri has not only some of the largest springs in the United States, but also hundreds of springs producing the most healthful drinking waters. Many of these are charged with magnesia, lithia, iron, sulphur, soda and potash, giving them unsurpassed medicinal qualities.

**Nickel and Cobalt.**

Nickel and cobalt occur, in small quantities, at Mine La Motte and the Catherine Mine in Madison county. The output during the last year sold for $5,964, exceeding that of all other parts of the United States. Nickel is used in certain alloys such as German silver; for plating iron; in storage batteries; in coinage; and to a small extent for medicinal purposes. Cobalt is valuable mainly for the intense blue color furnished by its protoxide. It is used in the arts especially for decorating porcelain and glass.

The nickel and cobalt ores in Madison county do not occur in sufficient quantity to pay for mining by themselves and the production is only incidental to the lead mining.

**Oil—See Gas.**

**Petroleum—See Gas.**

**Pyrite.**

Pyrite is valued entirely for the sulphur content which under normal conditions amounts to 53.4 per cent. Within the last few years there has been an increasing demand for iron pyrites in the manufacture of sulphuric acid and fertilizers. Pyrite occurs very widely disseminated through both the igneous and sedimentary rocks, but seldom is it concentrated sufficiently in one place to constitute a workable deposit.

The largest bodies in the state occur associated with the iron ores in some of the abandoned iron mines; as lenses and beds in the coal deposits; and as irregular lenticular masses associated with the lead of

INTERIOR VIEW OF THE MUSEUM.

Washington and neighboring counties. A good grade is worth from $4.00 to $5.00 per ton on board cars.

**Sand.**

Large quantities of sand are used each year for moulding, plastering, filtering, manufacturing glass and many other purposes. It is estimated by the United States Geological Survey, that the annual consumption in the United States amounts to about 900,000 tons.

The sand used for foundry purposes in Missouri is largely obtained from alluvial deposits along the river. That used for filtering and glass manufacturing is largely obtained from the sandstone which occurs so abundantly at Pacific, Klondike, Silica and other places located on the so-called saccharoidal sandstone in the eastern part of the State.

Saccharoidal sandstone in many places is almost pure silicon dioxide. It is soft and friable and can usually be broken down with a pick and shovel. The unlimited supply of this sand in the neighborhood of Pacific accounts very largely for the location of the large Plate Glass works which are now being erected at Valley Park.

The importance of sand as a commercial product will sometime warrant the Bureau in publishing a special bulletin on the Silica deposits of Missouri.

**Sandstone.**

The sandstone quarried in 1901, according to the report of the United States Geological Survey, amounted to $42,170. The stone was used building constructions, paving, concrete, sidewalks, crosswalks, road making, grindstones and other miscellaneous purposes. There is perhaps no more desirable stone for sidewalks and crosswalks than a well indurated sandstone. It wears well and is not slippery. For building constructions much of the sandstone in Missouri is of excellent quality. It is thought that the sandstones of the Cambro-Ordovician formations should be used more extensively than at present.

**Tripoli.**

Tripoli, in Missouri, consists of very pure decomposed chert. It occurs in several places in the State, but the only consderable quantity is mined at Seneca in Newton county. The output of ground silica from the quarries at this place in 1901 amounted to 3,600,000 pounds, according to the State Mine Inspector's report. The product is nearly pure silica and is used for the manufacture of filters; in the form of powder as an abrasive; and in the manufacture of polishing paste and dynamite.

Three companies are operating at this place, two of which are engaged altogether in the manufacture of filters, blotters, etc. The third besides manufacturing filters, is engaged in grinding the silica for abrasive purposes. The capacity of the American Tripoli Company is 4,000,000 pounds of powder and 50,000 filters. The Seneca Filter Company works about six to eight hundred tons of the stone into filters at its plant and ships about an equal amount to East St. Louis where it is ground. The National Tripoline Company uses its output entirely for manufacturing filters. The waste is shipped as it comes from the quarry.

The deposits about Seneca are confined to a radius of about ten miles. They are in Lower Carboniferous rocks and vary in thickness from two to twenty feet.

**Zinc (See under Lead).**

## LABORATORY.

The Bureau is very glad to receive specimens of any character—ores, minerals, stone or clay—and will examine carefully all such specimens and make a report to the individual sending them. Such examination will include a determination of the kind of mineral, rock or clay—but not a quantitative analysis or assay of the specimens.

However, the general work of the Bureau requires many analyses and assays in the preparation of special economic reports, and for the purpose of making these determinations, a well equipped laboratory should be provided. The Bureau should have a fully equipped chemical, physical and metallurgical laboratory—where it is possible not only to make chemical analyses of minerals and physical tests of structural materials, but where experiments in the concentration and reduction of zinc and lead ores may be constantly carried on. Any decrease in the cost of mining and milling these ores is equivalent to increasing the productiveness of the mines and if this can be brought about through the maintenance of a laboratory by the State there is entire justification in its establishment.

## FIRE PROOF VAULT.

The building in which the Bureau is at present housed is not fire proof. There is constantly more or less danger of fire and should such a misfortune befall the Bureau, there would be no way of saving the records. So long as the Bureau is housed in a building without fire protection, there should be a fire proof vault provided in which to keep the note books, maps, manuscripts and records of the department. Provision must be made in some way to insure the safety of the Bureau property.

## RECOMMENDATIONS.

The Bureau appreciates the inadvisability of attempting to prepare at once reports on all the resources reviewed in the foregoing pages. We recognize, however, the importance of placing this department on a basis which will meet the demands made upon it by the citizens of the State. We also appreciate the fact that a generous support of the State Bureau of Geology and Mines means proportionately more work in Missouri through co-operation with the United States Geological Survey. In topographic work alone, the United States Survey will cover every dollar appropriated by the State for this specific purpose. For every dollar this legislature appropriates for topographic work, the United States Survey will appropriate another. If $10,000 is appropriated to the Bureau for this work, there will be expended in Missouri through the plan of co-operation with the United States Geological Survey $20,000. As has been before stated some of the states have been entirely mapped under this arrangement. Ohio, is now appropriating $25,000 a year to carry out this plan of co-operation. The topographic maps have nothing to do with the geology of the region covered, but constitute a necessary basis for making a geological survey. Where a geologist is provided with a topographic map, on which to indicate the geology, he can work about twice as rapidly as where he is obliged to make his own map. It is of inestimable importance that a country should be mapped topographically before being surveyed geologically.

Recognizing this condition we feel that an item of $5,000 a year or $10,000 for the biennial period for topographic work should be one of the first considerations in the allotment of an appropriation to the Bureau for the next biennial period.

As stated above it is very important that work be continued as rapidly as possible in the preparation of geological reports on the fifty-two counties which, as yet, have not had even a reconnoissance report. For this purpose and for the administration of the Bureau, an appropriation of $10,000 a year or $20,000 for the biennial period is pre-eminently necessary.

The preparation of economic reports on the various mining industries—lead, zinc, barite, coal, clays, cements, etc., perhaps serve to promote interest in these industries more directly than any of the other publications of the Bureau. They not only serve as an aid to the miner in intelligent prospecting and mining, but also serve as the very best advertisement of the State's resources. An appropriation of less than $5,000

a year or $10,000 for the biennial period would do scant justice to this important work.

The Bureau has several other functions which should not be overlooked. The law directs the Bureau to bring together specimens in the form of a cabinet which will adequately represent the resources of the State. I interpret this as meaning that the Bureau should have among its collections not only fossils and rocks representing the stratigraphy of the State, but that it should bring together collections of minerals and ores which will interest and instruct, not only the scientific but also the industrial world. The Bureau should contain representative exhibits from all the producing mines of the State, and these exhibits should be accompanied by maps, charts and drawings illustrating the working of the mines.

The Bureau does not have such a collection today, although there are many valuable specimens in the cabinet. Such collections as are in the Bureau at present are not so classified or arranged as to be of the greatest value. Through the removal of the collections from Jefferson City to Rolla, they became somewhat badly disarranged. They have never been catalogued and many of the fossils have not been named.

The library of the Bureau is increasing in importance each year, and valuable additions are being constantly made in the shape of government reports and serial publications of American and foreign scientific societies. The volumes in the library have never been catalogued and it now takes an unnecessarily long time to find reports which are needed in the work of the Bureau. Both the specimens in the Museum and the books in the library should be catalogued and systematically arranged in the cases, in order to serve best the purposes for which they have been brought together. As previously mentioned the Bureau should devote some time to the preparation of type suites of minerals, ores, rocks and clays for distribution to the colleges and high schools of the State.

An assistant should be employed to catalog, classify and arrange the museum specimens and the books in the library and arrange suites of specimens for the colleges and prominent high schools of the State. However, the urgent needs of the Bureau are so many that provision for this item must be postponed until another biennial period.

We would therefore respectfully report that there is needed to carry out the most imperative work of the Bureau, during the next biennial period, a sum of not less than $40,000.

# APPENDIX.

## LIST OF PUBLICATIONS AND INDEX.

The following is a list of the publications of this Bureau up to the present time. The editions of all, with the exception of Volume I, on Coal Deposits; Volume XIII on Structural and Economic Geology; The New Year's Announcement; Biennial Report to the 41st General Assembly; Part II of Vol. XII; and the Biennial Report to the 39th General Assembly have been exhausted. They can only be obtained by purchase from second-hand book store.

### GEOLOGICAL SURVEY, 1839-1840.*

(Henry King, State Geologist.)

1. *Report of a Geological Reconnoissance* of that part of the State of Missouri adjacent to the Osage river, made to William H. Morell, chief engineer of the State, by order of the Board of Internal Improvement, by Henry King, M. D., Geologist. (Senate Journal, Appendix, 1st Session, 11th General Assembly, pages 506-535.) Jefferson City, 1840.

### GEOLOGICAL SURVEY, 1853-1861.

(George C. Swallow, State Geologist.)

2. *First and Second Annual Reports* of the Geological Survey of Missouri, by G. C. Swallow, State Geologist, 448 pages, 17 plates, 18 sections, 26 figures and 5 maps, 8vo., cloth. Jefferson City, December, 1855.
3. *Third Report of Progress,* of the Geological Survey of Missouri, by G. C. Swallow, 3 pages, Jefferson City, December, 1856.
4. *Fourth Report of Progress,* of the Geological Survey of Missouri, by G. C. Swallow, 8 pages. Jefferson City, December, 1858.
5. *Fifth Report of Progress,* of the Geological Survey of Missouri, by G. C. Swallow, 13 pages. Jefferson City, December, 1860.

* In this list the publications of the Survey are arranged in the order in which they were transmitted for publication.

GEOLOGICAL SURVEY, 1870-1871.

(Albert D. Hager, State Geologist.)

6. *Annual Report of the State Geologist,* of the State of Missouri, by Albert D. Hager, 23 pages. Jefferson City, December, 1870.

GEOLOGICAL SURVEY, 1871-1873.

(Raphael Pumpelly, State Geologist.)

7. *Report of the Geological Survey* of the State of Missouri, 1855-1871, by G. C. Broadhead, F. B. Meek and B. F. Shumard, 327 pages, 29 illustrations and 9 maps, 8vo, cloth. Jefferson City, March, 1873.
8. *Preliminary Report on the Iron Ores and Coal Fields,* from the field work of 1872, by R. Pumpelly, A. Schmidt, G. C. Broadhead and W. B. Potter, 671 pages, 190 illustrations and an atlas with 14 large sheets, 8vo, cloth. Jefferson City, April, 1873.

GEOLOGICAL SURVEY, 1873-1874.

(Garland C. Broadhead, State Geologist.)

9. *Report of the Geological Survey* of the State of Missouri, including field work of 1873-1874, by G. C. Broadhead, 794 pages, 91 illustrations and an atlas of 15 sheets, 8vo, cloth. Jefferson City, August, 1874.

GEOLOGICAL SURVEY, 1874-1876.

(Charles P. Williams, State Geologist.)

10. *Industrial Report on Lead, Zinc and Iron,* together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D., Acting State Geologist, 199 pages and 11 illustrations, 8vo, cloth. Jefferson City, December, 1876.

GEOLOGICAL SURVEY, 1889-1894.

(Arthur Winslow, State Geologist.

11. *Bulletin No.* 1—By Arthur Winslow, G. E. Ladd, A. E. Woodward and G. Hambach, 85 pages and 2 sketch maps. Jefferson City, April, 1890.
12. *Bulletin No.* 2—A Bibliography of the Geology of Missouri, by F. A. Samson, 76 pages, 810 titles. Jefferson City, December, 1890.
13. *Bulletin No.* 3—By G. E. Ladd and A. E. Woodward, 101 pages, 4 plates, 3 sections and 2 sketch maps. Jefferson City, December, 1890.

14. *Biennial Report of the State Geologist,* transmitted to the 36th General Assembly, Arthur Winslow, State Geologist, 53 pages, 2 diagrams. Jefferson City, January, 1891.
15. *Bulletin No.* 4—A description of some Lower Carboniferous Crinoids from Missouri, by S. A. Miller, 40 pages and 5 plates. Jefferson City, February, 1891.
16. *Bulletin No.* 5—By Erasmus Haworth and G. E. Ladd, 86 pages, 5 plates and 5 figures. Jefferson City, July, 1891.
17. *A Preliminary Report on the Coal Deposits of Missouri,* by Arthur Winslow, 226 pages, 131 illustrations and 1 map, 8vo, cloth. Jefferson City, November, 1891.
18. Vol. II. *A Report on the Iron Ores of Missouri,* by F. L. Nason, 366 pages, 8 plates, 62 illustrations and 1 map, 8vo, cloth. Jefferson City, December, 1892.
19. Vol. III. *A Report on the Mineral Waters of Missouri,* by Paul Schweitzer, including notes of A. E. Woodward, 256 pages, 23 plates, 11 figures and 1 map, 8vo, cloth. Jefferson City, December, 1892.
20. *Biennial Report of the State Geologist,* transmitted to the 37th General Assembly, Arthur Winslow, State Geologist, 37 pages, 3 diagrams. Jefferson City, January, 1893.

## GEOLOGICAL SURVEY, 1894-1897.

**(Charles R. Keyes, State Geologist )**

21. Vol. IV. *Paleontology of Missouri (Part I),* by C. R. Keyes, 271 pages, 32 plates and 9 figures, 8vo, cloth. Jefferson City, June, 1894.
22. Vol. V. *Paleontology of Missouri (Part II),* by C. R. Keyes, 266 pages, 24 plates and 2 figures, 8vo, cloth. Jefferson City, June, 1894.
23. Vol. VI. *Lead and Zinc Deposits (Part I),* by Arthur Winslow, 387 pages, 12 plates and 71 figures, 8vo, cloth. Jefferson City, July, 1894.
24. Vol. VII. *Lead and Zinc Deposits (Part II),* by Arthur Winslow, 383 pages, 29 plates and 268 figures, 8vo, cloth. Jefferson City, July, 1894.
25. Vol. VIII. *Annual Report with Accompanying Papers,* by C. R. Keyes, 395 pages, 30 plates, 16 figures and 1 map, 8vo, cloth. Jefferson City, December, 1894.
26. *Biennial Report of the State Geologist,* transmitted to the 38th General Assembly, C. R. Keyes, State Geologist, 60 pages, Jefferson City, January, 1895.

27. Vol. IX. *Reports on Areal Geology* (*Sheets* 1-4), by C. R. Keyes, A. Winslow, C. H. Gordon, Erasmus Haworth and F. L. Nason, 430 pages, 22 plates, 53 figures, 3 folio plates and 4 maps, 8vo, cloth. Jefferson City, April, 1896.
28. Vol. X. *Surface Features of Missouri and Bibliography* by C. R. Keyes, C. F. Marbut and J. E. Tood, 533 pages, 22 plates and 24 figures, 8vo, cloth. Jefferson City, June, 1896.
29. Vol. XI. *Clay Deposits,* by H. A. Wheeler, E. M., 622 pages, 39 plates, 15 figures and 2 maps, 8vo, cloth. Jefferson City, November, 1896.
30. *Biennial Report of the State Geologist,* transmitted to the 39th General Assembly, C. R. Keyes, State Geologist, 63 pages, 7 plates and 2 figures. Jefferson City, December, 1896.

## GEOLOGICAL SURVEY, 1897-1901.

**(John A. Gallaher, State Geologist).**

31. Vol. XII. *Areal Geology* (*Sheets* 5-10), E. M. Shepard, C. F. Marbut and G. C. Broadhead, edited by C. F. Marbut, 656 pages, 13 plates, 39 figures and 6 maps, 8vo, cloth. Jefferson City, December, 1898.
32. *Biennial Report of the State Geologist,* transmitted to the 40th General Assembly, by John A. Gallaher, State Geologist, 68 pages. Jefferson City, December, 1898.
33. *New Year Announcement of the Bureau of Geology and Mines,* by J. A. Gallaher, State Geologist, 27 pages. Jefferson City, January, 1900.
34. *Preliminary Report on the Structural and Economic Geology of Missouri,* by John A. Gallaher, State Geologist, 260 pages, 65 plates, 9 sections and 6 figures, 8vo, cloth. Jefferson City, September, 1900.
35. *Biennial Report of the State Geologist,* transmitted to the 41st General Assembly, by Leo Gallaher, Act. State Geologist, 55 pages. Jefferson City, January, 1901.

## GEOLOGICAL SURVEY (SEPT., 1901, TO DATE.)

**(Ernest R. Buckley, State Geologist.)**

36. Biennial Report of the State Geologist, transmitted to the 42nd General Assembly, by E. R. Buckley, State Geologist, 83 pages, 8 plates. Jefferson City, January, 1903.

REPORTS IN PRESS OR READY FOR PUBLICATION.

Vol. I, 2nd Series—Geology of Miller county.
Vol. II, 2nd Series—Quarrying Industry.

REPORTS IN PREPARATION.

Vol. III, 2nd Series—Geology of Morgan and Moniteau counties.

## COUNTY INDEX OF PUBLICATIONS.

The following is a brief index of the above listed reports of the Bureau of Geology and Mines as far as they pertain to the different counties in the State. The abbreviations used are as follows:

S. I & II—First and Second Annual Reports of the Geological Survey of Missouri, by G. C. Swallow.

P. I. 1855-71—Report of the Geological Survey of the State of Missouri, by G. C. Broadhead, F. B. Meek and B. F. Shumard.

P. I. 1872—Preliminary Report on the Iron ores and Coal Fields, by R. Pumpelly, A. Schmidt, G. C. Broadhead and W. B. Potter.

B. I. 1873-74—Report of the Geological Survey of the State of Missour, by G. C. Broadhead.

W. I. 1875-76—Industrial Report on Lead, Zinc and Iron, together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D.

Bul. No. 1—Administrative Report; The Coal Beds of Lafayette county, by Arthur Winslow; The Building Stones and Clays of Iron, St. Francois and Madison counties, by G. E. Ladd; A Preliminary Catalog of the Fossils occurring in Missouri, by G. Hambach.

Bul. No. 2—A Bibliography of the Geology of Missouri, by F. A. Sampson.

Bul. No. 3—The Clay, Stone, Lime and Sand Industries of St. Louis City and county, by G. E. Ladd; The Mineral Waters of Henry, St. Clair, Johnson and Benton counties by A. E. Woodward.

Bul. No. 4—A description of some Lower Carboniferous Crinoids from Missouri, by S. A. Miller.

Bul. No. 5—The Age and Origin of the Crystalline Rocks of Missouri, by Erasmus Haworth; Notes on the Clays and Building Stones of Certain Western Central counties Tributary to Kansas City, by G. E. Ladd.

I—A Preliminary Report on the Coal Deposits of Missouri, by Arthur Winslow.

II—A Report on the Iron Ores of Missouri, by F. L. Nason.

III—A Report on the Mineral Waters of Missouri, by Paul Schweitzer.

IV—Paleontology of Missouri (Part I), by C. R. Keyes.

V—Paleontology of Missouri (Part II), by C. R. Keyes.
VI—Lead and Zinc Deposits (Part I), by Arthur Winslow.
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VIII—Annual Report with Accompanying Papers, by C. R. Keyes.
IX—Reports on Areal Geology (Sheets 1-4), by C. R. Keyes, A. Winslow, C. H. Gordon, Eramus Haworth and F. L. Nason.
X—Surface Features of Missouri and Bibliography, by C. R. Keyes, C. F. Marbut and J. E. Todd.
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# FINANCIAL STATEMENT SHOWING THE EXPENDITURE OF THE BUREAU OF GEOLOGY AND MINES

From January 1, 1901-January 1, 1903.

EXPENDITURES DURING 1901 UNDER THE ACTING STATE GEOLOGISTS.

| | |
|---|---|
| Leo Gallaher—April 20, July 1—Salary | $953 81 |
| Leo Gallaher—April 20, July 1—Traveling expenses | 84 32 |
| Leo Gallaher—July 1—Miscellaneous | 1 50 |
| A. C. McLaughlin—April 20, July 1—Salary | 600 00 |
| A. C. McLaughlin—April 20, July 1—Traveling expenses | 46 00 |
| D. K. Greger—April 22, May 23—Salary | 473 33 |
| D. K. Greger—May 23—Traveling expenses | 10 35 |
| James K. Hull—May 8—Salary | 40 00 |
| James K. Hull—May 8—Traveling expenses | 103 95 |
| E. M. Shepard—July 1, Sept. 1—Salary | 450 00 |
| E. M. Shepard—July 1, Sept. 1—Traveling expenses | 124 08 |
| G. W. B. Garrett—April 2, May 18—Expenses | 110 45 |
| O. A. Crandall—May 20—Expenses | 9 95 |
| John S. Logan—May 18—Expenses | 17 30 |
| H. H. Gregg—June 29, Aug. 21—Expenses | 66 70 |
| Robt. Wright—April 22, Aug. 6—Office expenses | 129 50 |
| Missouri, Kansas and Texas Railway | 25 |
| Etta L. Carter—April 20, July 1—Salary | 300 00 |
| Tribune Ptg. Co.—April 24, Aug. 29 | 5 00 |
| Western Union Telegraph Co.—May 3, June 6—Telegrams | 8 80 |
| Pacific Express Co.—May 1, July 1—Express charges | 15 37 |
| American Express Co.—May 3, July 6—Express charges | 8 60 |
| H. A. Swift—April 22, July 5—Sundries | 5 85 |
| Scientific Publishing Co.—April 23 | 5 00 |
| Missouri Pacific Ry.—April 27 | 19 57 |
| Geo. E. Robinson—April 30 | 41 00 |
| Dan Gundelfinger—May 9 | 1 10 |
| Press Printing Co.—May 18 | 8 50 |
| Jos. Goldman—June 15 | 10 00 |
| Colliery Engineer Co.—June 15 | 6 00 |
| Regis Chauvenet & Bro.—June 15 | 5 00 |
| Wyckoff, Seamans & Benedict—Aug. 8 | 50 00 |
| S. M. Greenridge—Aug. 8 | 5 00 |
| A. M. Dockery—Aug. 14 | 9 50 |

EXPENDITURES FOR 1901 UNDER THE PRESENT ADMINISTRATION.

1901.

| | |
|---|---|
| E. M. Shepard—Oct. 9, Dec. 9—Expenses | $148 25 |
| H. H. Gregg— Dec. 3—Traveling expenses | 37 50 |
| Etta L. Carter—Nov. 16—Salary | 50 00 |
| Tribune Prtg. Co.—Oct. 5, Dec. 7—Printing and paper | 178 20 |
| H. A. Buehler—Nov. 7—Salary | 60 00 |
| J. S. Hammon—Nov. 7—Salary | 13 50 |
| E. R. Buckley—Sept. 12, Nov. 7—Salary | 440 00 |
| E. R. Buckley—Nov. 7—Traveling expenses | 91 80 |
| Office expenses—Sept. 12, Nov. 1— | 126 96 |
| J. S. Hammon—Dec. 5—Salary | 18 45 |
| H. A. Buehler—Dec. 6—Salary | 40 00 |
| E. R. Buckley—Dec. 6—Salary | 250 00 |
| E. R. Buckley—Dec. 6—Traveling expenses | 31 70 |
| Office expenses—Dec. 6 | 98 19 |
| S. H. Ball—Dec. 24—Salary | 64 71 |
| S. H. Ball—Dec. 24—Traveling expenses | 26 21 |
| E. B. Craighead—Nov. 7—Traveling expenses | 95 45 |
| W. & L. E. Gurley—Nov. 26—Instruments | 96 00 |
| R. R. Dickerson—Sept. 21—Repairs to building | 238 70 |

1902.

| | |
|---|---|
| E. R. Buckley—Jan. 7, March 31—Salary | 750 00 |
| E. R. Buckley—Jan. 7, March 31—Traveling expenses | 76 21 |
| Office expenses—Jan. 7, March 31 | 115 92 |
| S. H. Ball—Feb. 5, April 5—Salary | 201 29 |
| S. H. Ball—Feb. 5, April 5—Traveling expenses | 155 18 |
| H. A. Buehler—Jan. 7, March 31—Salary | 120 00 |
| H. A. Buehler—Jan. 7, March 31—Traveling expenses | 36 10 |
| A. F. Smith—Jan. 7, March 1—Salary | 190 00 |
| A. F. Smith—Jan. 7, March 1—Traveling expenses | 156 46 |
| Lena J. Strobach—Jan. 7, March 31—Salary | 95 00 |
| J. S. Hammon—Jan. 7, March 5—Salary | 57 15 |
| E. R. Buckley—April 2, June 3—Salary | 750 00 |
| E. R. Buckley—April 2, June 3—Traveling expenses | 191 48 |
| Office expenses—April 2, June 3 | 355 34 |
| S. H. Ball—May 5, July 7—Salary | 180 00 |
| S. H. Ball—May 5, July 7—Traveling expenses | 176 98 |
| H. A. Buehler—April 2, June 3—Salary | 120 00 |

| | |
|---|---|
| H. A. Buehler—April 2, June 3—Traveling expenses.... | 151 33 |
| A. F. Smith—April 11, June 3—Salary..... | 180 00 |
| A. F. Smith—April 11, June 10—Traveling expenses..... | 173 13 |
| Lena J. Strobach—April 11, June 3—Salary..... | 75 00 |
| J. S. Hammon—April 4 May —Salary..... | 35 70 |
| E. R. Buckley—July 7, Sept. 16—Salary..... | 750 00 |
| E R. Buckley—July 7, Sept. 16—Traveling expenses..... | 146 11 |
| Office expenses—July 7, Sept. 16..... | 562 29 |
| S. H. Ball—Aug. 7, Oct 8—Salary..... | 180 00 |
| S. H. Ball—Aug. 7, Oct. 8—Traveling expenses..... | 39 16 |
| H. A. Buehler—July 7, Sept. 16—Salary..... | 300 00 |
| H. A. Buehler—July 7, Sept. 16—Traveling expenses.... | 133 91 |
| A. F. Smith—July 2, Sept. 16—Salary..... | 180 00 |
| A. F. Smith—July 2, Sept. 16—Traveling expenses..... | 107 14 |
| C. F. Marbut—Aug 11—Salary..... | 103 90 |
| Lena J. Strobach—July 7, Sept. 16—Salary..... | 75 00 |
| F. B. Laney—June 3, Nov 7—Salary..... | 153 33 |
| F. B. Laney—June 3, Nov. 7—Traveling expenses..... | 246 29 |
| Carl Smith—Aug. 7, Oct. 8—Traveling expenses..... | 112 40 |
| E. M. Shepard—June 13, Aug. 18—Traveling expenses.. | 48 75 |
| W. S. Allee—Jan. 7, Aug. 18—Traveling expenses..... | 46 15 |
| C. F. Marbut—Sept. 16, Oct. 8—Salary..... | 110 00 |
| C. F. Marbut—Sept. 16, Oct. 8—Traveling expenses.... | 135 36 |
| T. J. Craig—Aug. 7, Sept. 16—Draughting..... | 99 00 |
| H. H. Gregg—May 12, Sept. 16—Traveling expenses.... | 34 70 |
| E. R. Buckley—Oct. 8, Dec. 6—Salary..... | 750 00 |
| E. R. Buckley—Oct. 8, Dec. 6—Traveling expenses..... | 69 47 |
| Office expenses—Oct. 8, Dec. 6..... | 213 60 |
| S. H. Ball—Oct. 8, Dec. 6—Salary..... | 120 00 |
| S. H. Ball—Oct. 8, Dec. 6—Traveling expenses..... | 131 73 |
| H. A. Buehler—Oct. 8, Dec. 6—Salary..... | 180 00 |
| H. A. Buehler—Oct. 8, Dec. 6—Traveling expenses..... | 84 65 |
| A. F. Smith—Oct. 8, Dec. 6—Salary..... | 180 00 |
| A. F. Smith—Oct. 8, Dec. 6—Traveling expenses..... | 69 42 |
| Lena J. Strobach—Oct. 8, Dec. 6—Salary..... | 50 00 |
| Tribune Printing Co.—Jan. 2, Oct. 17..... | 57 09 |
| Graham Paper Co.—January, Oct. 15..... | 27 00 |
| G. A. Fisher—Dec. 6—Office expenses..... | 2 10 |
| Lawrence May—Oct. 8—Salary ..... | 10 50 |
| R. W. McConnell—Sept. 16—Traveling expenses and salary ..... | 97 30 |
| Catherine Luckett—Nov. 7—Salary ..... ..... | 25 00 |

| | |
|---|---|
| A. T. Sweet—Oct. 8—Traveling expenses | 14 40 |
| Otto Veatch—Oct. 8—Traveling expenses | 19 90 |
| Library Bureau—Feb. 17 | 248 80 |
| E. B. Craighead—Sept. 11 | 52 45 |
| E. R. Buckley—Dec. 6—Jan. 1—Salary | 250 00 |
| E. R. Buckley—Dec. 6, Jan. 1—Traveling expenses | 9 45 |
| Office expenses—Dec. 6, Jan. 1 | 33 50 |
| S. H. Ball—Dec. 6, Jan. 1—Salary | 46 00 |
| H. A. Buehler—Dec. 6, Jan. 1—Salary | 60 00 |
| H. A. Buehler—Dec. 6, Jan. 1—Traveling expenses | 18 60 |
| A. F. Smith—Dec. 6, Jan. 1—Salary | 60 00 |
| Lena J. Strobach—Dec. 6, Jan. 1—Salary | 25 00 |
| Jesse Parker—Nov. 1, Jan. 1—Salary | 35 25 |
| E. M. Shepard—Nov. 1, Jan. 1—Traveling expenses | 42 20 |
| E. B. Craighead—Nov. 1, Jan. 1—Traveling expenses | 34 70 |
| Total | $16,755 30 |

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MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

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# BIENNIAL REPORT

OF THE

# STATE GEOLOGIST

TRANSMITTED BY THE

# BOARD OF MANAGERS

OF THE

# BUREAU OF GEOLOGY AND MINES

TO THE

## Forty-Third General Assembly.

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS

# MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

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## BOARD OF MANAGERS.

His Excellency, Alexander M. Dockery, Governor of Missouri, Ex-officio President of the Board.....Jefferson City
Professor Edward M. Shepard, Sc. D., Vice-President.....Springfield
*President E. B. Craighead, A. M., LL. D., Secretary....Warrensburg
Hon. H. H. Gregg.....Joplin
Hon. W. S. Allee, M. D.....Olean
**Hon. Cecil M. Baskett.....Mexico

*Resigned. Moved from the State.

**Appointed to fill the unexpired term of Dr. Craighead.

# PREFATORY LETTER.

Bureau of Geology and Mines,
Rolla, Mo., Dec. 31, 1904.

To the President, Governor A. M. Dockery, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines for the years 1903 and 1904, as required by law. The work of this department has reached all parts of the State and has dealt with every variety of mineral, clay and stone resource. The brief summary contained in the following pages, expresses very inadequately the extent of this work and its importance to the industrial development of the commonwealth.

On behalf of my associates and myself I desire in this place to express to you, the members of the Board of Managers, my appreciation of the interest you have taken in the work of the Bureau. As individuals and as a body you have contributed very largely to whatever success may have attended the work of this department.

The Bureau is completely and carefully organized and must in the future, as in the past, render valuable service to the people.

Your obedient sir,

E. R. BUCKLEY,
Director and State Geologist.

# STAFF OF THE BUREAU OF GEOLOGY AND MINES.

Ernest Robertson Buckley, Ph. D.....Director and State Geologist
Henry A. Buehler, B. S.....Assistant State Geologist
Arthur F. Smith, B. S.....Assistant Geologist
Frank B. Van Horn, B. S.....Assistant Geologist
Curtis F. Marbut, M. S.....Assistant Geologist
(Employed during the Summer field season.)
Miss Lena J. Strobach.....Clerk and Stenographer

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# CHAPTER I.

## THE AIMS AND OBJECTS OF THE BUREAU OF GEOLOGY AND MINES.

Most of the progressive states, in which mining is an important industry, have either a Geological Survey or a Bureau of Geology and Mines. Among these states might be mentioned Texas, Louisiana, Alabama, North Carolina, Georgia, Ohio, Indiana, Wisconsin, Michigan, Iowa, Minnesota, New York, Pennsylvania, Virginia, West Virginia, Maryland, New Jersey and Missouri.

The geological bureau or survey in each state constitutes a storehouse in which information relative to the mineral resources, (metallic and non-metallic), is collected; and from which anyone interested in the development of the mineral resources may obtain information. Information bearing on the mineral resources is collected and systematically filed for reference, to be given out again in response to inquiries. These geological bureaus also collect information systematically on the different mining resources,—one or two at a time,—and examine carefully all the mineral resources of counties,—one or more at a time, as the appropriation will permit,—in order to publish reports wherein these observations may be permanently recorded

The work which this Bureau is commissioned to do is clearly defined in the following chapters of the law creating the Missouri Bureau of Geology and Mines:

"Sec. 7503. It shall be the duty of the State Geologist and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the State, already begun, with a view to determine the order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the several strata or geological formations within the State, and to discover and examine all beds or deposits of mineral contents and fossils, and to determine the various position, formation and arrangement of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters and other mineral substances as may be useful or valuable; also, to note carefully the character of the soils and their capacities for agricultural purposes, the growth of timber

and other scientific matters that may be of practical importance and interest; and said geologists shall cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances, and, on the completion of the survey, to complete a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey. (R. S. 1889, § 5262.)

Sec. 7504. It shall be the duty of the State Geologist to make or cause to be made detailed maps and reports of counties or districts as fast as completed, which maps shall embrace all such geological, mineralogical and scientific details necessary to make complete reports of said districts or counties. The State Geologist may also, from time to time, publish or cause to be published any reports of work completed, in the form of pamphlets or bulletins for general distribution. (R. S. 1889, § 5263.)

Sec. 7505. It shall be the duty of the State Geologist to collect full suits of all materials, rocks, ores, fossils or other mineral substances of scientific or practical interest or utility as may be discovered, and that may be necessary to form a complete cabinet collection, to illustrate the various resources of the State, as may be necessary to assist in preparing the various reports of the survey. (R. S. 1889, § 5264.)

Sec. 7506. It shall be the duty of the said assistants to make full and complete examinations, assays and analyses of all such rocks, ores, soils or other substances as may be submitted to them by the State Geologist for the purpose, and to furnish him with a detailed and complete account of the results so obtained. (R. S. 1889, § 5265.)

Sec. 7507. The State Geologist, from time to time, may furnish items of general information or new discoveries for publication in newspapers: Provided, the preparation of the manuscript and publication thereof does not interfere with the progress or add to the expense of the survey; he may also have authority to furnish cabinets for colleges or public museums, located within the State of Missouri, of minerals, rocks, or fossils: Provided, said institutions shall pay the expense of preparing, labeling, transporting and putting up said collection, and also, further, that in the selection of said specimens the general State collection is not deprived of duplicates of the same, and that the State collection is not seriously injured. (R. S. 1889, § 5266.)

Sec. 7503b. On the presentation of a petition to the State Geologist signed by not less than fifty freeholders who reside in the neighborhood of lands situated in any county in this State which they may believe to

contain valuable or have found valuable ores, clays, rocks, coals, mineral oils or mineral matter, said petition being certified by the clerk of the county court in which the petitioners reside to contain the names of fifty freeholders residing within the neighborhood of the lands, which lands shall be described in the petition according to government surveys, it shall be the duty of the State Geologist in person or by assistants as soon as practicable to examine and inspect said lands and make report and map as to existence on said lands of valuable ores, clays, coals, mineral oils or mineral matter found, and embody the same in his report now directed to be made by section 7563, Revised Statutes of Missouri, 1899.

Briefly the work of this Bureau is as follows:

1st. To ascertain the relations existing between the different rock formations at or near the surface of the earth and prepare county reports containing maps, drawings and other illustrations setting forth these facts and giving the thickness, surface distribution, structure and characteristics of each formation.

2nd. To examine the metallic and non-metallic mineral resources, including stone, clay, cement, road materials, soils, water, lead, zinc, iron, coal, petroleum, asphalt, copper, barite, sand, etc., publishing complete reports outlining their distribution and describing their manner of occurrence.

3rd. To collect, name and arrange a collection of specimens illustrating the geology and mineral resources of the State; also to assist the colleges and schools in the making of similar collections.

4th. To examine ores, rocks, soils, clays, and other mineral specimens for citizens of the State, reporting as to the kind and value of any specimen submitted for examination.

5th. To disseminate, everywhere, correct ideas as to the occurrence, origin, and relation of ores, minerals and rocks, for the purpose of increasing the general intelligence of the public on matters pertaining to geology and mining.

6th. To answer all inquiries relative to the mineral resources of the State.

7th. To examine, upon petition of fifty freeholders, lands upon which ores, clays, stone or other mineral resources of value may be thought to exist.

8th. To co-operate with the United States Geological Survey and other bureaus of the United States Government where benefit will accrue to the State.

The ultimate purpose of this work is to aid in the development of the mineral resources (metallic and non-metallic),—1st, by preparing

maps, charts and reports which will assist the prospector in carrying on his work with greater accuracy and a higher degree of intelligence; 2nd, by calling the attention of the public to undeveloped and partly developed resources; 3rd, by examining and reporting on specimens submitted by citizens of the State to this department; 4th, by increasing the general intelligence of the public through the sending out to colleges and public schools mineralogical and geological collections and published reports and addressing mining clubs and other organizations; 5th, by answering inquiries relating to the mineral resources of the State.

The work of a bureau of this character, when properly conducted, pays for itself, in dollars and cents, many fold. This return to the State comes about through the assistance, in the form of advice, given individuals, relative to mining and prospecting. Intelligent advice may result (1) in the development of an important mining or quarrying industry, or (2) in preventing the expenditure of money in localities where the chance of discovering minerals or ores of value is very slight. In the first instance, the result is an increase in the taxable property, while in the second case the result is a saving of taxable property. You cannot tax a man for a hole in the ground, even though it may have cost fifty thousand dollars. On the other hand, if the same sum were expended in developments on land where ores of value are to be found, the land may increase in taxable value ten or perhaps a hundred fold. It is difficult to estimate the extent to which the Bureau of Geology and Mines is responsible for increasing and saving the taxable property of the State, but if it were possible to measure the results in dollars and cents, our people would have no hesitancy in giving this departmnet the most generous support.

On the other hand, if the State were to maintain this Bureau simply to conduct investigations for the purpose of increasing our scientific knowledge of the geology and mineralogy of the State, they would be doing nothing more, proportionately, than is being done by other states, by the United States and by foreign countries.

Complaint is frequently made that geological reports are too technical to be useful to the public and are consequently of little value. Those who write these reports are not altogether responsible for this condition. It must be recognized that this is not so much a defect in the published reports as in the individual, who evidently expects to read geological literature, understandingly, without first familiarizing himself with the elements of that science. The same person, however, would not attempt to read a volume on "Plant Morphology" without first acquainting himself with the elements of botany. If men do not have the time and inclination to first acquire the elementary principles of

geology they ought not condemn the reports for containing words and phrases which they, themselves, do not understand.

Probably the Bureau of Geology and Mines should provide a series of reports dealing with the elementary principles of Geology and Mineralogy. I believe that such a set of reports, taking the place with the public that the primer does in the public school, would very greatly enhance the value of the more or less technical reports of this department. Such a set of reports, in which the illustrations were mainly drawn from Missouri, could be used to advantage in the public schools, increasing very greatly the student's knowledge of the physical geography and mineral resources of the State.

In writing the reports of this Bureau special care has been taken to use language and terms which may be understood by the public, and thus, not only remove cause for criticism, but increase the value and usefulness of the publications. In one of the volumes, in which it was necessary to use a considerable number of uncommon words, a glossary has been inserted in which these terms are defined. As to how well we have succeeded in writing semi-technical reports in language that all may understand, we must leave the public to judge.

# CHAPTER II.

## EMPLOYEES, EQUIPMENT AND PUBLICATIONS.

This is practically the only bureau of the State government which is devoted to investigations requiring a technical training. It is practically the only department which demands of its employees that they have a technical knowledge of the subjects with which it is concerned. Yet it is understood that simply a technical training in geology and mineralogy does not fit one for the work of this department. The employees must be able to use their scientific training and knowledge in reaching conclusions, and then, finally, they must have the ability to so express themselves that the public may understand.

The Bureau is not intended to be a training school for students and the employees should be men of experience, who have received an education which fits them to carry on geological investigations, without other assistance than may come from careful supervision and direction.

The assistants in this Bureau, during the entire administration, have been chosen solely with regard to their ability. No other consideration has entered to influence the Board of Managers in their selections. The success, which has been attained, is in a large measure due to the Board having adhered strictly to this rule. One of the chief reasons for the efficiency of the U. S. Geological Survey has been that the selection of the men employed thereon has been in no way influenced by political considerations.

Since 1891, the work of this Bureau has been constantly interrupted by changes of administration. At the end of each four year period a new staff has been appointed. This has occasioned a great loss to the people of the State through the non-publication of unfinished reports. It requires several years for one to familiarize himself with the various geological problems in a State of this size, and, whenever there is a change in the directorship of the Bureau, the State loses thereby. In order to minimize the loss, provided there should be a change in administration, there has been inaugurated, during the last three years, a card catalog system of keeping and classifying the records. This system makes a great part of the data which have been collected during the last three years available to anyone who may succeed to this office. This system was fully outlined in the last biennial report and will not be dis-

cussed here. It suffices to say that these records have been kept up, as close as practical, and are now in good shape.

*Library.* A library, which is well stocked with reference books, public reports and current periodicals, is very necessary for the work of this Bureau. A geological library is as indispensible to the geologist as a law library is to a lawyer. Recognizing this fact, an attempt has been made to accumulate all the geological literature possible through exchanging the publications of the department for those of other similar organizations. As a result of such exchanges we now have between four and five thousand books and phamplets dealing with geological and mining subjects. There have been no funds available for the purchase of needed books, for which reason the library lacks many volumes which would be of great assistance in the investigations now being carried on.

The books and phamplets in the library have been arranged systemmatically in the cases and cataloged according to a card index system, especially adapted to our needs.

During the last biennial period about 300 books and pamphlets have been received in exchange for the publications of the Bureau. There are now, about four thousand volumes in the library. Many of the volumes, chiefly those from foreign countries, are unbound. It is difficult to preserve a book without binding and as soon as an adequate appropriation can be secured these volumes should be bound.

*Museum.* The law creating the Bureau charges it with the collection, arrangement and naming of specimens illustrating the geology and economic resources of the state, and to assist the colleges and schools of the State to make similar cabinet collections. During the last biennial period about five hundred specimens have been added to the collections making in all about 6,000 specimens now in the Museum. The specimens lately collected represent chiefly the lead and zinc ores of the state. As the different counties are surveyed, specimens, representing the geology and mineral resources of these counties as individuals, are collected. It is expected eventually to arrange these county collections, each by itself, and to add to them from time to time, as opportunity may permit.

*Publications.* The work of this Bureau is represented, in part, by the publication of reports. These are of three kinds; 1st—Biennial reports; 2nd—County reports; 3rd—Economic reports. The biennial reports are intended chiefly to provide the legislature and the public with a summary of the work of the department and a retrospect of

the mining developments during each biennial period. They do not contain the results of the investigations carried on by the Bureau, inasmuch as it has been deemed wise to separate the administrative reports from those of a more technical and scientific nature.

During the last two years, two volumes of special reports have been published, one on "The Geology of Miller County" and another on "The Quarrying Industry." Two additional volumes are completed, one of which would have been published had there been sufficient appropriation. These reports are on "The Geology of Moniteau County" and "The Geology of Morgan County." Three other reports are in preparation, one on "The Geology of St. Francois County;" another on "The Geology of Newton County;" and a third on "The Lime and Cement Industries."

The county reports are based on a most careful investigation of every section of land, as well as all accessible mines, prospects, quarries and clay-banks in the county. They are accompanied by maps, showing the distribution of the economic resources and the various geological formations; cross sections, showing the structure and relations of the rock formations; and reproductions of photographs of mining and geological formations in the county. These are complete reports, thereby differing from the reconnaissance reports of Swallow, Broadhead and the other early geologists.

The nature of these reports can be understood better, by an examination of the volumes than through their description. The following outline of the report on Moniteau County, which is in press, will give one an idea of what is embodied in these reports.

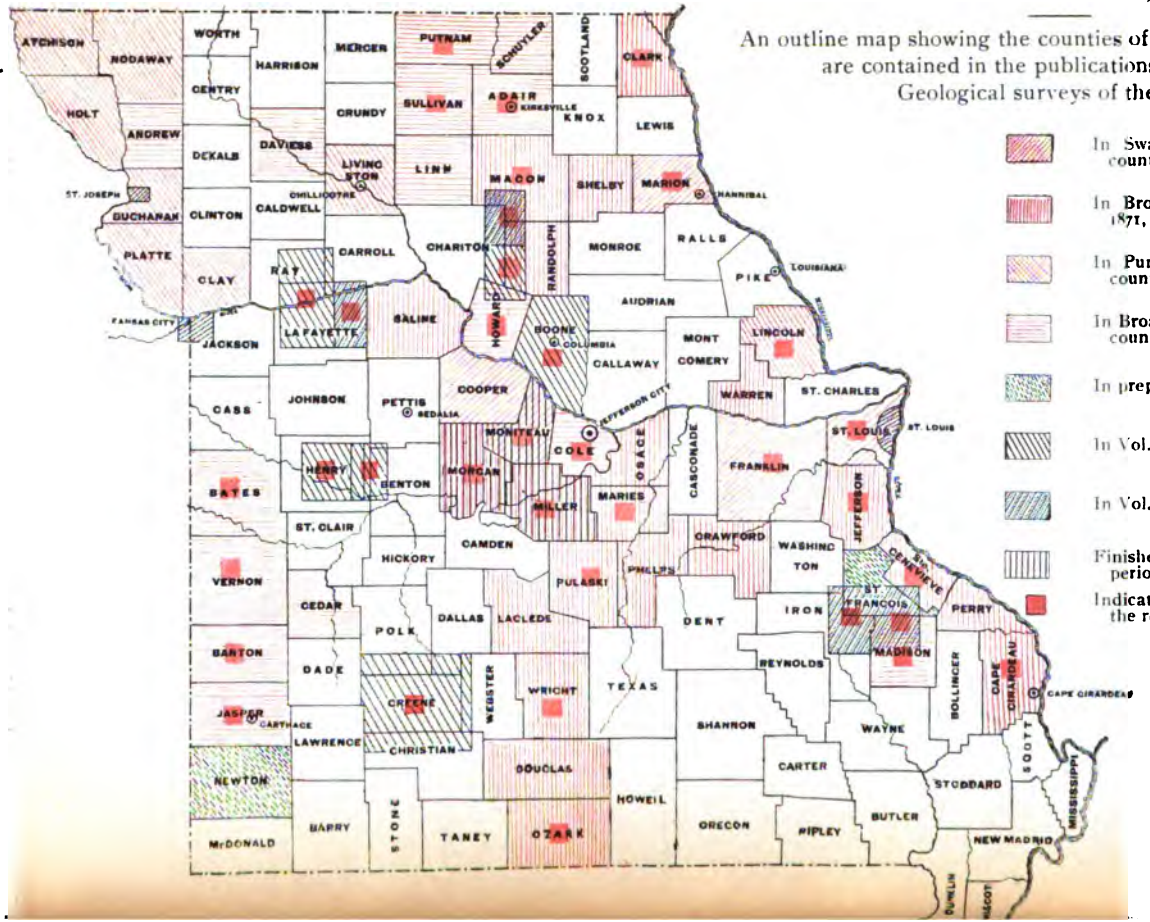
THE GEOLOGY OF MONITEAU COUNTY.

Chapter I. Introduction.
" II. Physiography.
A. Types of surface relief.
(1) Alluvial Plains.
(2) The Hilly area.
(3) The Table-land.
(4) Relation of physiography to industrial and social conditions.
B. Caves and Sinks.
C. Table of Elevations.
D. River Systems.
(1) Missouri River.
(2) South Moreau.
(3) The Moreau.
(4) Moniteau.
(5) Factory.
(6) Little Splice.
(7) Big Splice.
(8) Petite Saline.

# MISSOURI BUREAU OF GEOLOGY AND MINES.

## BIENNIAL REPORT FOR 1903-04, PL. II.

An outline map showing the counties of which special reports are contained in the publications of the earlier Geological surveys of the State.




In Swallow's Report of 1855, 5 counties.

In Broadhead's et al. Reports of 1871, 21 counties.

In Pumpelly's Report of 1872, 8 counties.

In Broadhead's Report of 1873, 15 counties.

In preparation.

In Vol. XII.

In Vol. IX.

Finished during last biennial period.

Indicates that maps are printed of the respective counties.

Chapter III. Stratigraphy.
- A. Cambro-Ordovician.
  - (1) St. Elizabeth Formation, (2nd sandstone and part of 3rd Magnesian Limestone of Swallow).
  - (2) Jefferson City Limestone, (2nd Magnesian Limestone of Swallow).
  - (3) St. Peter's, (Pacific sandstone or 1st Sandstone of Swallow).
- B. Devonian.
  - Onondaga limestone.
- C. Carboniferous.
  - (1) Mississippian, (Lower Carboniferous).
    - (a) Chouteau limestone.
    - (b) Burlington limestone.
  - (2) Pennsylvanian (Upper Carboniferous).
    - (a) Graydon sandstone.
    - (b) Saline Creek cave-conglomerate.
    - (c) Shale and Coal.
- D. Pleistocene.
  - Glacial boulders.
- E. Recent.
  - (1) Soil.
  - (2) River Alluvium.
  - (3) Travertine.
- F. General section.

Chapter IV. Geological Structure.
- A. Folding.
- B. Faulting.
- C. Jointing.
- D. Unconformities.

Chapter V. Economic Considerations.

(A.) Barite. (B.) Building stone. (C.) Cement. (D.) Clay. (E.) Coal. (F.) Iron. (C.) Lime. (H.) Lead and Zinc. (I.) Road Materials. (J.) Sand. (K.) Soils. (L.) Water Supply.

The areas which have been mapped and for which reports have been published up to date are shown on the accompanying map. The counties covered with red lines are those for which reconnaissance reports have been published. The counties covered with black lines are those for which detailed reports have been published or are in preparation. Those for which maps, either reconnaissance or detailed, have been published are indicated by red squares in the center of the county.

One economic report has been published during the last biennial period and a second is in preparation. The published report deals with the quarrying industry and especially with the building and ornamental stones. Very little reference is made in this volume to the manufacture of quicklime and cement, it being the intention to discuss these in a second volume which is now being prepared.

The character of these reports can be best judged by an examination of the volume which has already been published, an outline of which will be found in the last biennial report. The report on "The Lime and Cement Industries" is expected to cover the field represented by the following outline:

LIME AND CEMENT INDUSTRIES OF MISSOURI.

PART I.

Chapter I. Limestone, Clay and Shale and their Uses.
" II. Quicklime and Cement and their Uses.

PART II.

*Quicklime and Hydraulic Cement.*

Chapter I. Composition and Characteristics.
" II. Methods of Manufacture.
" III. The Slacking and Setting Properties.
" IV. Methods of Testing.

PART III.

*Portland Cement.*

" V. Composition and Characteristics.
" VI. Methods of Manufacture.
" VII. The Setting Properties.
" VIII. Methods of Testing.

PART IV.

*Mortar, Concrete, Artificial Stone, Etc.*

" IX. Composition and Methods of Making.
" X. Methods of Testing.

PART V.

*Quicklime and Cement Industries in Missouri.*

" XI. History of the Lime and Cement Industries in Missouri.
" XII. Stone in Missouri Suitable for the Manufacture of Quicklime.
" XIII. Stone in Missouri Suitable for the Manufacture of Cement.
" XIV. Quality of Missouri Lime and Cement.
" XV. Miscellaneous tables showing comparative values of Limes and Cements.

In addition to the maps and reports prepared by this department there has been prepared through a co-operative arrangement with the U. S. Geological Survey six topographic maps covering the areas indicated on the accompanying map. Besides this, work on another area has been begun as indicated on the map. These maps may be obtained from the U. S. Geological Survey or this Bureau for five cents a copy.

On December 1, 1904, the following volumes of the reports of this Bureau remained for distribution:

| | |
|---|---|
| Preliminary Report on Coal Deposits, by Arthur Winslow | 55 |
| Preliminary Report on Structural and Economic Geology, Vol. XIII., 1900, by John A. Gallaher | 3,095 |
| New Year's Announcement, Jan. 1, 1901, by John A. Gallaher | 433 |
| Biennial Report of the State Geologist to the 41st General Assembly, by Leo Gallaher | 463 |
| Areal Geology, Vol. XII., Part II., by C. F. Marbut and G. C. Broadhead | 195 |
| Biennial Report of the State Geologist to the 39th General Assembly, by Charles R. Keyes | 173 |
| Geology of Miller County, Vol. I., 2nd Series, 1903, E. R. Buckley, A. F. Smith and S. H. Ball | 2,125 |
| The Quarrying Industry of Missouri, Vol. II., 2nd Series, 1904, by E. R. Buckley and H. A. Buehler | 3,159 |
| Biennial Report of the State Geologist to the 42nd General Assembly by E. R. Buckley | 560 |

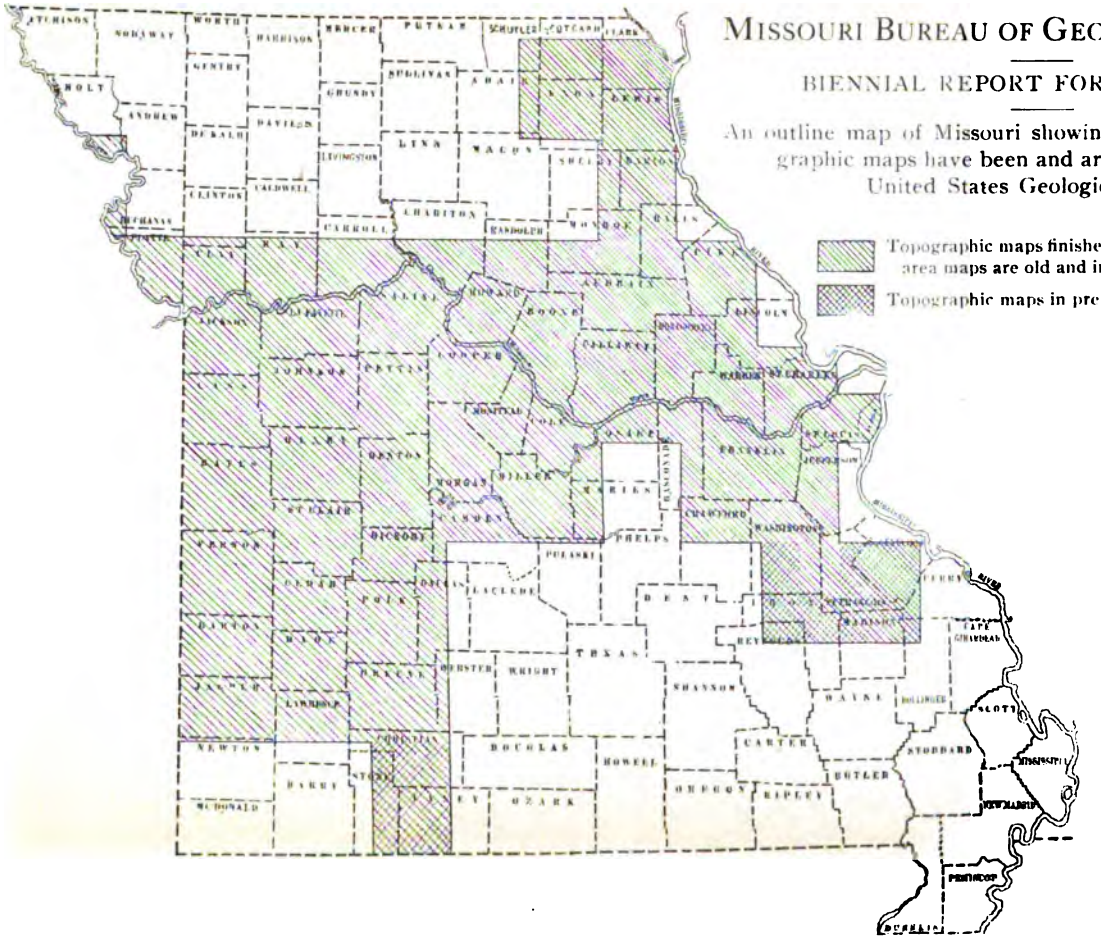
# Missouri Bureau of Geology and Mines.

## Biennial Report for 1903-04 Pl. III.

An outline map of Missouri showing areas for which Topographic maps have been and are being made by the United States Geological Survey.

Topographic maps finished. Over about two-thirds of this area maps are old and inaccurate, must be re-surveyed.

Topographic maps in preparation or planned for.



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Vols. I and XIII, 25c each; Vol. XII, Pt. 2, 25c.; Vol. I, 2nd Series, 25c.; Vol. II, 2nd Series, 40c.; all others 10c.

The biennial report transmitted to the 42nd General Assembly contains a list of the publications of this Bureau and an index giving the volumes in which the geology of the different counties is discussed or referred to.

*Miscellaneous Work.* The publications represent only a small part of the work of the Bureau. There is a constant accumulation of data bearing on geology and mining in the State which are used for the purpose of answering intelligently the numerous inquiries which are received relative to the State's mineral resources. Scarcely a day passes that we are not called upon to examine specimens for some citizen who has little or no knowledge of geology. Through the mail we receive many inquiries concerning the mineral resources of different sections of the State. We answer correspondence which extends from Canada to Mexico and from the Pacific to the Atlantic. It has been our intention to answer to the best of our ability every inquiry no matter how unimportant or trivial it might seem.

In this connection we have been called upon to examine and report upon various localities in the State where the citizens have petitioned for the examination of mineral lands in accordance with law. The reports made in this connection will be found in the following chapter.

# CHAPTER III.

## REPORTS SUBMITTED IN ANSWER TO PETITIONS.

In 1901 the legislature passed a law directing the State Geologist to examine and report upon lands in any county in this State upon presentation of a petition signed by not less than fifty freeholders residing in the neighborhood of said lands, which they may believe to contain valuable or upon which they have found valuable, "ore, clays, rocks, coals, minerals, oils or mineral matter," said petition to be certified to by the clerk of the County Court in which the petitioners reside.

Since the passage of this law no specific appropriation has been made to carry out its provisions. Occasional petitions have been made and each has been answered in person either by the State Geologist or his assistant, the expenses being met out of the general appropriation for the Bureau.

The law does not require that the results of the examinations be published in the biennial report but rather in the final reports. It is believed, however, that the interests of the citizens are better conserved by publishing the results of these investigations in the biennial reports.

The following are copies of the reports made, during the last two years, in answer to petitions.

### REPORT ON THE LENOX AND PARRY IRON COMPANY'S MINES.

Located in the S. W. ¼ of the N. E. ¼ of Sec. 32, T. 37, R. 6W.

These mines were examined on the 20th of January, 1903, in company with Mr. Lenox, Mr. Parry and others. The purpose of this inspection was to furnish an opinion as to the average quality of the ore and to make an estimate of the approximate amount of ore in sight.

The ore consists of soft, red hematite, limonite and blue specular hematite. In places the red hematite is soft and breaks down into a reddish brown powder. As a rule, however, the ore remains in pieces large enough for the furnace. The specular hematite is hard and in places appears to be siliceous.

All of the ore must be blasted before it can be removed from the mine, which, in itself, is evidence of the firmness of the ore. From an examination of the ore piles at the surface, and without making chemical analyses, one can say that the ore from this mine is a very good quality.

The fine dust-like product which constitutes a small part of the ore, ought to be suitable for the manufacture of mineral paint.

It was estimated that the three ore piles contained from 1,500 to 1,700 tons of ore ready to be shipped to the furnace. In the larger drift, it was estimated that there was from 5,000 to 7,000 tons of ore blocked out. In the second drift, it was estimated that there was in the neighborhood of 2,000 tons of ore in sight. It is thought that a conservative estimate of the ore in sight would place the amount at about 10,500 tons.

The ore is hauled from one of the drifts by a cable drawing a car up an incline. From the other drift the ore is hoisted through a shaft by horse power. It is dumped in piles, afterwards loaded into wagons and hauled about 5½ miles to what is known as the Winkler Spur of the St. Louis and San Francisco Railroad. When cars cannot be obtained, the ore is dumped onto a platform and from there later loaded into cars. The method of handling the ore is expensive and if possible a more economical arrangement should be provided.

It is thought that improved railroad facilities might increase very materially the output of this bank as well as induce the opening up of other iron ore deposits in the immediate vicinity.

Respectfully submitted,

E. R. BUCKLEY.

REPORT ON THE REGION CONTIGUOUS TO DIAMOND GROVE AND NEOSHO.

An examination of lands in the neighborhood of Diamond Grove, Neosho and Granby emphasizes very strongly the probability that the Joplin-Carthage-Webb City district will find its continuation in this direction.

The occurrence of extensive areas of Mississippian limestone and chert overlain with areas of Pennsylvanian shale, as in the Joplin district, offers the first evidence to substantiate the proposition that ore bodies will be found in this region. The limited and unsystematic prospecting already carried on, usually not deeper than 100 feet, has demonstrated that the underground waters of this region have been richly charged with zinc and lead, in solution. Conditions favorable to ore deposition are shown by the occurrence of rich deposits of galena and "silicate" near the surface

It appears now to be mainly a question of finding those areas where there was an abundnt circulation of the mineral bearing solutions through openings in the strata and under conditions which occasioned precipitation. There is little doubt but that such areas will be found,

as they have been in the now developed Joplin district. It will require, however, systematic prospecting to a depth of at least two hundred or two hundred and fifty feet to prove the land. The people of Neosho and Diamond Grove should be especially active in bringing the right men into the district that prospecting may be systematically and intelligently carried on.

At the time of my visit special attention was called to the old "Conner Diggings" and I was very much gratified with the results of the investigation. The prospecting at this place has uncovered several feet of residual flint and clay carrying ten to fifteen per cent (estimated) of galena. At another place, about a quarter of a mile south, surface explorations have resulted in uncovering several tons of silicate ore. These occurrences of ore show the former presence of mineralized solutions which may have formed extensive deposits of zinc blende, where conditions were favorable, perhaps at greater depths.

A generous, organized effort on the part of the people living and owning property in this region, to bring to the knowledge of prospectors the favorable conditions which exist in the Diamond Grove-Neosho region should result in extensive search for bodies of lead and zinc ores.

Very respectfully yours,

E. R. BUCKLEY.

REPORT ON PETITION FROM LACOMA.

Mr. A. C. Aldrich et al., Lacoma, Mo.:

Gentlemen—On June 12th, 1903, in company with an assistant, I made an examination of portions of the East ½ of the N. W. ¼; S. W. ¼, N. E. ¼; N. E. ¼, S. W. ¼; and E. ½, S. W.¼ of Sec. 2, T. 35, R. 8W., in reply to a petition submitted January 24, 1903.

This land is mainly underlain with Gasconade limestone, although the ridges and ravines, in a number of places, display some sandstone belonging to the overlying St. Elizabeth formation.

A few pieces of galena have been picked up in the overlying soil, but none of the galena so found was in the rock.

It is possible that some of the crevices which show at the surface may carry galena at a greater depth. This can only be demonstrated by sinking shafts or drilling into the formation. It cannot be said that there are any especially favorable conditions at the surface and one is led to doubt the advisability of prospecting by sinking shafts, unless a place with more favorable indications should be found.

Very sincerely,

E. R. BUCKLEY.

### EXAMINATION OF LANDS NEAR BUCKLIN.

Mr. G. L. Joyce, Attorney-at-Law, Bucklin, Mo.:

Dear Sir—In accordance with a request made by yourself and others living in the vicinity of Bucklin, I have made an examination of secs. 1 and 12, T. 57, R. 18W., and secs. 7 and 8, T. 57, R. 17W.

From such examination of the surface as I was able to make, I am led to believe that all of that area between the east line of secs. 6 and 7 and the township of Bucklin, is favorably situated for the occurrence of coal. It is impossible for one to say how many or how thick the veins, underlying this area, may be. These facts can only be determined by drilling or sinking shafts. I believe that systematic prospecting with a core drill, would be the most advantageous way to prove this territory.

This is a matter which should interest every one in your city and that portion of the country tributary to it. The situation of the land and the surface indications are such as to warrant your people in making some concerted effort to have the land prospected.

If I can be of any further assistance to you in this matter, I will appreciate having you call on me.

Very respectfully yours,

E. R. BUCKLEY.

### REPORT ON PETITION FROM SHELDON.

Dr. C. C. Brand, Sheldon, Mo.:

Dear Sir—In compliance with a petition signed by yourself and other freeholders of Vernon county, I made an examination of the following described lands, for the purpose of ascertaining if there were any evidences of metallic ores, coal, asphaltic rock, oil or gas.

N. W. ¼ sec. 18, T. 34, R. 29; S. E. ¼ of S. W. ¼ and S. ½ of the S. E. ¼ and N. E. ¼ of S. E. ¼ and S. E. ¼ of N. E. ¼ and the N. W. ¼ of the S. W. ¼, S. W. ¼ of S. W. ¼, S. W. ¼ of N. W. ¼, S. W. ¼ of N. E. ¼, N. W. ¼ of S. E. ¼, N. W. ¼ of N. E. ¼ and N. E. ¼ of N. W. ¼, sec. 27, T. 34, R. 30W. and S. W. ¼ of the S. E. ¼ of sec. 12, T. 34, R. 30W.

The only mineral resources of this area which can be reported as a result of this examination, is asphaltic sandstone which underlies a considerable portion of the area examined. Shallow drill holes in the N. E. ¼ of the S. W. ¼, sec. 24, T. 34, R. 30W., show 27½ feet of asphaltic rock. This rock begins about 12 feet below the surface at the place where the holes were drilled. In the draw or ravine leading up to the drill holes, the asphaltic or bituminous sandstone outcrops at the

surface. At one place it has been quarried to a depth of several feet. There was considerable rock on the dump, most of which was heavily impregnated with bitumen or asphalt. At this place a hole had been drilled 1135 feet deep and it is reported that 32 feet of asphaltic rock was passed through near the surface.

An excavation in the creek bed in the N. W. ¼ of sec. 18, T. 34, R. 29W., reached the bituminous or asphaltic sandstone. Near this place, on a farm owned by Hall and Popplewell, there is a well, the bucket of which is coated with asphalt which evidently seeps out of the rock and rises to the surface of the water in the well. This well is 27 feet deep.

In the S. W. ¼ of the S. E. ¼ of sec. 12, T. 34, R. 30W., a seam of coal was examined which is rich in bitumen. The seam occurs about 10 feet from the surface, is 22 inches thick and is overlain with sandstone. Wherever the coal is encountered in this region, it is from 12 to 36 inches thick.

A hole had been bored in the S. E. ¼ of the S. W. ¼ of sec. 27, T. 34, R. 30W., to a depth of 1306 feet. At a depth of 15 to 16 feet bituminous or asphaltic sandstone was encountered. The asphaltic sandstone is reported to be 21 feet thick and underlain with 17 feet of fire clay.

In the S. W. ¼ of S. W. ¼ of sec. 27, T. 34, R. 30W., bituminous or asphaltic sandstone outcrops along the sides of a bluff and near the heads of the ravines. During warm weather the bitumen is reported to ooze out along the bedding planes of the exposed rocks. Two small shafts sunk in the rock each show sandstone heavily impregnated with asphalt. Near the line of sec. 28, the bituminous sandstone outcrops within two feet of the surface. Two shafts which have been sunk in this sandstone are partly filled with water, on top of which the bitumen floats in considerable quantity.

From an examination which was made in this locality, I am convinced that there is an almost inexhaustible supply of bituminous or asphaltic sandstone of good quality. I believe that in some places the sandstone is sufficiently rich in asphalt to warrant the erection of a plant for the extraction and preparation of the asphalt for commercial uses. The early development of these deposits of asphaltic sandstone will depend quite largely upon the attitude assumed by the owners of the land toward those who wish to make developments. This is a comparatively new field and in order to interest those who have capital, the land owners must assume a generous policy.

Respectfully submitted,

E. R. BUCKLEY.

REPORT ON PETITION FROM HARVIELL.

Mr. L. Knickerbocker, Naylor, Mo.:

Dear Sir—In compliance with a petition signed by yourself and other citizens of Naylor, I made an examination of certain lands in the vicinity of Harviell, Missouri, on which prospecting was being carried on. Such examination as I was able to make, led to the conclusion that insufficient development had been done to warrant an expression of opinion relative to the probable occurrence of lead or zinc ores. The two shafts are not sufficiently deep for one to determine the character of the formation in which they have been sunk. The presence or absence of valuable minerals cannot be shown except through systematic prospecting over a considerable area and to greater depths than that to which the present shafts have been sunk.

Respectfully submitted,

E. R. BUCKLEY.

REPORT ON LANDS IN THE VICINITY OF MONTICELLO.

Judge F. L. Marchand et al., Monticello, Mo.:

Gentlemen—In answer to a petition received August 13, 1904, I have made an examination of the lands described in said petition and would respectfully report as follows:

Either coal or carbonaceous shale were found at three different places on the land inspected. These deposits occur in the N. W. ¼ of the N. W. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W.; in the S. W. ¼ of the N. W. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W.; and in the middle of the W. ½ of the N. E. ¼ of the N. E. ¼ of sec. 5, T. 61, R. 7W. At the locality first described, there is a thickness of from 14 to 48 inches of bituminous coal, of very good quality. At the other two localities, no coal was observed. The shale and coal both occur at practically the same elevation. Coal was reported to have been found near the line between the S. E. ¼ and the N. E. ¼ of sec. 30, T. 62, R. 7W., and near the east line of the N. E. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W. At the time of my visit, neither coal nor shale were found at these places, probably as a result of the valleys having been filled with sand and silt as a result of the recent heavy rains.

Information gathered relative to deep well borings near the exposures of coal and shale, indicates that coal does not underlie the more elevated land west and north of the coal mine. This is confirmed by observations made on the outcroppings of rock in the immediate vicinity of the coal mine. If the coal seam extended over a considerable area, it would

outcrop at numerous places along the branches at the same elevation, since the beds lie practically horizontal. As it is, I observed sandstone at the same elevation as the coal in many places on the land owned by Mr. Smith and others in the vicinity of the mine. On Thomas Johnson's land, there is an exposure of carbonaceous shale, but on either side and within a few rods, there are thick beds of sandstone where the shale should be, if it continues uninterruptedly through the hill. On the land owned by Mr. Sayre, there is an outcrop of shale in a branch. This shale is local as is shown by the way it pinches out against the sandstone as it is followed up the branch.

Every evidence, both in the coal mine and outside of it, points to the fact that the deposit of coal in the N. W. ¼ of the N. W. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W., is a so-called pocket and does not continue underneath the prairie land to the west and north. The amount of coal in the pocket can only be determined by drilling outside of the known limits of the coal. I not only believe that the coal seam is limited in extent, but I also believe that there is no coal seam beneath the one now being worked.

I think you would be justified in drilling a few holes immediately around the coal mine, within a radius of 100 feet, in order to determine the actual amount of coal in the deposit. These holes should not exceed 100 feet in depth. If you should find coal in the holes drilled within a radius of 100 feet of the mine, then I would suggest that you drill other holes 200 feet from the mine. In this way you can determine very closely the amount of coal in the pocket which you are now mining.

Respectfully submitted,

E. R. BUCKLEY.

Director and State Geologist.

### REPORT ON PETITION FROM GOLDEN.

Mr. Henry Clay et al., Golden, Mo.:

Gentlemen—In answer to your petition, the following described lands were examined on September 11 and 12, 1903, viz: the N. E. ¼ of the S. W. ¼ and the S. E. ¼ of the N. W. ¼ of sec. 18, T. 21N., R. 25, owned by Mr. Henry Clay and the S. E. ¼ Sec. 6, T. 21, R. 25, belonging to Mr. L. L. Wall.

The general topography of the country is very rough. At this place the White river flows northeast, in a channel 150 to 250 feet below the tops of the surrounding hills. The land examined lies at one of the lowest points in the district, being practically surrounded by hills which rise from 500 to 700 feet above the river level. The drainage diverges at this place to the west, north and south, as shown by Roaring

river which flows west, Rock creek south and Owl creek north. Owl creek, which flows along the west side of the Clay prospect, has a large catchment basin to the south.

The surface rock consists of "cotton rock," dolomite and flint belonging to the Cambro-Ordovician succession. The dolomites, in general, are fine grained and compact. A ten-foot bed of sandstone occurs in the strata about 25 feet above the bed of Owl creek, near the Clay prospect. The beds are approximately horizontal and in no place exhibit marked deformation. The beds have a slight general dip to the north and are gently folded. The joints are, as a rule, tight. One normal fault, having a displacement of 3 feet 8 inches was observed in the bluff just west of the shaft. It dips 27° to the south and strikes N. 70°W. Apparently this fault is not accompanied by brecciation.

On the hillside east of the shaft, occurs a rather thin brecciated or porous bed of flint, out of which, during rainy weather, water seeps. Occasionally crystals of zinc blende or "jack" occur in this bed.

The development work at this place consists of one combined shaft and drill hole, 100 feet deep, and one drill hole 40 feet deep. The 40-foot drill hole is just east of Owl creek, while the shaft is 250 feet east of the creek and 35 feet above the creek bed. The shaft is located on a continuation of the fault mentioned above. The following section shows the succession of beds passed through in the shaft and drill hole as recorded by Mr. Clay. The cuttings from the drill hole were not available for examination and the section could not be verified below the depth of the shaft. In the shaft zinc blende was found in only one bed as hereinafter noted.

| | | | |
|---|---|---|---|
| No. 1. | Drift | 2½ ft. | |
| " 2. | Sandstone | 10 ft. | |
| " 3. | Mud opening | 8 ft. | |
| " 4. | Fine grained dolomite | 16 ft. | |
| " 5. | Fine grained dolomite | 2½ ft. | No shines. |
| " 6. | Gray rock | 3 ft. | Shines. |
| " 7. | Gray rock | 3½ ft. | Lead and jack. |
| " 8. | Flint | 3 ft. | Jack shines. |
| " 9. | Gray flint | 4 ft. | Jack, copper and lead shines. |
| " 10. | Blue flint | 3 ft. | Jack and flint. |
| " 11. | Gray rock | 3½ ft. | Few shines. |
| " 12. | Gray rock and flint | 6 ft. | No shines. |
| " 13. | White flint | 1½ ft. | Quartz and mundic. |
| " 14. | Flinty white rock | 1½ ft. | No jack. |
| " 15. | White and brown rock | 4 ft. | Jack. |
| " 16. | Brown rock | 5 ft. | Quartz and considerable jack. |
| " 17. | Brown rock | 2 ft. | Good jack. |
| " 18. | White rock | 2 ft. | Quartz and jack. |
| 19. | White rock and flint | 1½ ft. | No jack. |
| " 20. | White and blue flint | 4½ ft. | Quartz and hard formation. |
| " 21. | Gray rock | 4 ft. | Few shines of lead and jack. |
| " 22. | Gray rock | 4 ft. | Supposed galena. |
| " 23. | Gray rock | 1 ft. | Jack. |

The two beds marked Nos. 16 to 18 and 22 and 23 reported as containing jack are soft rock. Just above the upper bed occurs a very fine grained compact ledge known locally as lithographic stone. Above the lower beds there is a very hard dense bed of flint. The mineral is reported as occurring in the soft stone just beneath these beds. The shaft has been sunk to the fine grained cap rock just above the first reported mineral bed. The upper portion of the shaft is practically barren. A thin bed containing crystals of pink dolomite and zinc blende was passed through at the level of the creek bed. This stratum containing pink dolomite and blende shows in the creek bed. For 30 feet, the shaft shows a fault with a displacement of one foot. The dip of the fault carries it outside of the shafts about 10 feet from the bottom. It is reported that small crystals of blende were found along this fault. Underground water conditions seem to indicate that the stratum directly underneath the fine grained rock at the bottom of the shaft is porous.

A thin bed of flint from 2 to 3 inches in thickness occurs 10 feet from the bottom of the shaft. This bed has been assayed by different assayers and has shown a large range of value in gold and silver. Assays made by this department, give the following results. Gold 0.00. Silver .48 Oz. per ton.

A number of the beds of limestone contain considerable asphaltic material.

*Conclusion.*

No indications of extensive mineralization were observed on the surface of the hills. A few small crystals of blende were found where single shots had been placed in the hillside. Very little loose mineral occurs at the surface. There is no indication of porous, broken or open strata above the present water level and there is little liability of extensive mineralization throughout this portion of the formation. The location of the shaft on this property is one of the best that could be made in this vicinity, being located on the above mentioned fault. In order to test the richness of the cuttings, I would advise sinking the shaft to the depth of the drill hole. This would be a matter of a small cost and will make a very good test of this ground.

The thin bed of flint, which was reported as quartz, does not contain enough silver to make it a commercial proposition.

Although asphaltic material occurs in a number of the beds, no indication was found that beneath the present level, there are extensive deposits of oil and gas.

### *Mr. Wall's Land.*

The land owned by Mr. Wall is located just south of the White river in the E. ½ of the S. E. ¼ of sec. 6, T. 21, R. 25. The same strata occur at this point as at the Clay prospect. Two shafts have been sunk upon this property,—one near the river and the other in a small ravine northeast of the house. These shafts were partly filled with water and an examination was impossible. From the material on the dumps the same succession of strata was apparent as at the Clay prospect, but neither shaft has been sunk to the depth of that on the Clay land. The beds are fine grained and show very little mineral.

Upon the hillsides, above the river, boulders of hematite were found but not in sufficient quantity to be of commercial value.

### CONCLUSION.

The same general conditions exist at this property as at that of Mr. Clay, and should the shaft be sunk to the same depth probably the same conditions would be found at both places. No faulting was noted in this vicinity.

Respectfully submitted,

H. A. BUEHLER,

Assistant State Geologist.

### REPORT ON PETITION FROM ALBANY.

Mr. C. N. McNeese et al., Albany, Mo.:

Gentlemen—In answer to your petition addressed to the State Geologist, I examined, on the 5th and 6th of October, 1903, the following described lands, to wit: the N W. ¼ of N. W. ¼ of sec. 20, and the N. E. ¼ of N. E. ¼ of sec. 13, all in T. 64, R. 30W.

This land is located east of the east branch of Grand river and has a rolling, hilly topography. The surface of the land is covered with a variable thickness of glacial drift, immediately underneath which lie the Upper Coal Measure strata. Owing to the thickness of the glacial drift, these rocks outcrop only along the stream channels or their branches. In this locality the Coal Measure strata consist mainly of heavy beds of shale, interstratified with thin beds of limestone. A coal seam outcrops along the north bank of McGinley branch on the land above described. This seam was worked before the war, but of late years has remained untouched. At the time this examination was made the coal seam was not exposed, but it is reported to have a thickness of

18 inches. Prior to making this examination, a new shaft was started on the hill north of the creek. This shaft was 23 feet deep at the time this examination was made, but the coal seam had not been reached. The shaft passed through about 20 feet of red clay into a sandy blue shale. Since making this examination the coal seam has been reached and samples have been forwarded to this office. In this shaft the seam is reported to be 18 or 19 inches thick, but about one-third of this is very soft. This may be due to the nearness of the shaft to the old tunnel.

A similar seam of coal was passed through in a well just north of Chalk Run on the land of James H. Hill, one mile south of the McNeese outcrop. The coal occurs at the same level but the exact thickness of the bed is not known. The strata at this point lie approximately level, and in all probability the coal bed is continuous between the two places.

The following analysis shows the composition of the coal from the shaft on the McNeese land:

| | |
|---|---|
| Water | 9.58% |
| Volatile Carbonaceous matter | 39.41 |
| Fixed carbon | 44.48 |
| Ash | 6.53 |
| | 100.00 |
| Total volatile matter | 48.99 |
| Coke | 51.01 |
| | 100.00 |
| Color of ash | dark brown. |
| Coke | firm lustrous. |

This analysis shows the coal to be of very good quality.

Beneath the coal occurs a bed of blue shale, the exact thickness of which is not known. A sample taken 2 feet below the coal gave the following analysis:

| | |
|---|---|
| $H_2O$, $CO_2$ | 11.12 |
| $SiO_2$ | 55.10 |
| $Al_2O_3$ | 27.52 |
| $Fe_2O_3$ | 1.95 |
| CaO | .62 |
| MgO | 1.51 |
| | 97.81 |

The undetermined constituents are the alkalies.

This shale is suitable for the manufacture of building brick and vitrified paving brick. It could also be used in the manufacture of Portland cement.

A bed of very similar shale, 15 feet thick, is exposed along a south branch of Muddy creek. Beneath this shale occurs a ledge of sandy limestone showing small streaks of carbonaceous material with occasional very thin stringers of coal.

At Denver, four miles north of the McNeese property, moderately heavy beds of limestone outcrop along the east branch of Grand river. The following is an analysis of a sample taken from the white bed near the mill at Denver:

| | |
|---|---|
| Insoluble matter | 2.34% |
| $Fe_2O_3Al_2O_3$ | .62 |
| $CaCO_3$ | 96.16 |
| $MgCO_3$ | .49 |
| Total | 99 61 |

This analysis shows the stone to be a very pure limestone which is admirably adapted for use in the manufacture of Portland cement.

## CONCLUSION.

The coal outcropping on the McNeese property is of very good quality, but the vein is not thick enough to be worked economically by itself. Should a brick plant be erected at this point to use the shale underlying the coal, the two might possibly be mined at a profit.

The limestone and shale are well suited to the manufacture of Portland cement. The outcrops are about four miles apart, although the same limestone and shale probably occur in closer proximity at other points.

Since the coal and shale are both located seven miles from a railroad, it is thought that neither can be economically developed on a large scale, until transportation facilities are provided.

Very respectfully submitted,

H. A. BUEHLER,

Assistant State Geologist.

# CHAPTER IV.

## FUTURE WORK AND NEEDS OF THE BUREAU.

*Examination of Specimens.* It is the duty of the Director or his assistants to examine all specimens sent to the Bureau by citizens of Missouri, furnishing such information as they can relative to the kind and value of the minerals. It might be desirable for the Bureau to make free analyses and assays of specimens, were it not for the fact that the privilege would be greatly abused and that it would be an infringment upon the field of the professional assayer and analyst. As it is, the Bureau can only advise whether or not the specimens are of such a nature as to warrant analysis. In the future, as in the past, we expect to make examinations of specimens and report as to their probable value.

*Chemical Laboratory.* A great many analyses of rocks and ores are needed in the preparation of the reports of the Bureau. For making these analyses, the Bureau is very poorly equipped. It is hoped that in the future we may have better laboratory facilities and be thereby better enabled to perform the chemical work needed.

*Laboratory for testing materials.* There is a constant demand on the part of citizens of the State for the testing of materials to determine their suitability for the manufacture of quicklime, cement, brick, terra cotta, pottery, etc. The testing of cement, quicklime, stone, brick, paving materials, etc., is important and can be best carried on in conjunction with this Bureau. This is the age of brick, terra cotta and cement, and the testing of these products and the materials for their manufacture should be carried on systematically in every state. It is our desire to make these tests, but without the necessary laboratory equipment, it is impossible to do so. The Bureau has neither a chemical nor a physical laboratory or the equipment for either.

*Topographic Maps.* The preparation of topographic maps prior to making a geological survey of a county reduces the cost of such survey about one-half and increases very greatly the accuracy of the work. It is positive that geological work in any area should be preceded by the making of topographic maps.

Missouri has not appropriated a dollar for topographic maps during the last four years, although through a co-operative arrangement and

for the purpose of stimulating an interest in this work, the U. S. Geological Survey has mapped five sheets and has begun the field work on another. The U. S. Geological Survey has expended in Missouri during the last two years about $17,000 in topographic mapping. This is a sum almost equal to the total appropriation made by the State for all kinds of geological work for the same period.

In order to insure the continuance of topographic mapping by the U. S. Geological Survey, a specific appropriation must be made for that purpose. The United States Survey is willing to make these maps in co-operation with this Bureau, each paying one-half of the cost. Under a similar plan of co-operation, Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, North Carolina, Georgia, Alabama, Ohio, Wisconsin, North Dakota, Colorado, Nevada, Idaho, Arizona and Texas are having or have had topographic maps made. Pennsylvania has been appropriating annually for this work $20,000. North Carolina has appropriated $10,000 annually. West Virginia has appropriated $15,000 annually. Ohio appropriates $25,000 annually. Other states have made similar allotments of money to be used for topographic mapping in co-operation with the U. S. Geological Survey.

Among other uses of topographic maps may be mentioned the following:

1. "*Educational.*—(a) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

2. *Practical.*—As preliminary maps for planning engineering projects. Highways, electric roads, railroads, aqueducts and sewerage plants may be laid out on them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs and routes of canals may be ascertained from these maps.

3. *Political.*—In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

4. *Administrative and Military.*—In all questions relating to Federal or State administrations of public works, as canals, reservations, parks, highways and as military base maps on which to plan works of offense, defense, camps, marches, etc.

5. *Statistical.*—As base maps for the graphic representation of all facts relating to population, industries, products or other statistical information.

6. *Economic.*—As a means for showing the location, extent and accessibility of lands, waters, forests and valuable minerals. In this re-

spect these maps are indispensable to State and Federal bureaus, and to owners, investors and corporations."

"In addition, as an incident in the making of a topographic map, monuments are established throughout the State, the positions of which are accurately determined by geodetic methods and which serve as datum points for all other Government, private and cadastral surveys. There are also established throughout the State bench marks or permanent monuments which furnish datum elevations for the future determinations of height in connection with all public or private engineering works. Meridian marks are established at each county seat, which aid local and county surveyors in determining the declination of their compasses and which thus greatly facilitate the search for old property lines."

"The maps that result from these co-operative surveys show, in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief, or surface forms, printed in brown, including the shapes of the hills, valleys and ravines, their elevations and depressions, and the slopes of every rise or fall in its surface of the land."

"The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating States have the benefit of this publication without further expense, and the residents of the State, as well as its officials, may purchase the maps at rates of 5 cents per sheet, or $2 per hundred." (Extract from a report of the Director of the U. S. Geological Survey.)

The United States Geological Survey will duplicate every dollar that is appropriated by the State specifically for topographic mapping. If this State were to appropriate $10,000 for this purpose the U. S. Government would spend $10,000 in addition. In this manner the topographic maps which are so valuable and necessary, both for commercial and scientific enterprises, may be obtained for one-half what they would cost if the State were to make them herself.

*County Geologic Reports.* The most important investigation entrusted to the Bureau is the completion of the geological survey of the State, which contemplates the preparation of complete reports on the geology and mineral resources of each county. It is the present plan to push this work as rapidly as possible, surveying first those counties for

which detailed reports have not been published. With the many other duties which the Bureau has been called upon to perform this work has progressed slowly during the last biennial period. A much larger appropriation is needed if it is desired to make these reports available within a few years. There are many counties where indications of rich mineral deposits occur, in which the prospector might be aided by such surveys as are now being made. Both the lead and zinc producing counties in the southern part of the State and the coal, clay and cement producing counties in the north would derive great benefit from the county geological reports could they be made.

*Economic Reports.* Reports dealing with special mineral resources and covering the entire State are very much needed. We have just issued a comprehensive report on "The Quarrying Industry" and have in preparation another volume on "The Lime and Cement Resources." Volumes treating of the "Coal Resources," "Barite," "Materials for Street Paving and Highway Constructions," "Lead," "Zinc," "Asphalt," etc., are being called for continually, but we have no reports on these subjects for distribution. A very important work for the future is the preparation of reports on these subjects.

*Physical Geography.* There are many requests for reports treating of the physical geography of the State. A report or a series of reports dealing with this subject would be of inestimable value for use in the public schools. The young must be educated along these lines if it is expected that the next generation will be more familiar with mining and kindred subjects than the present. There is no better way to increase the general intelligence of the public than by the issuance of reports of this character in which the illustrations are drawn from the hills, valleys, prairies and plains of our own State.

We propose in the near future, whenever there is sufficient appropriation, to publish reports of this character.

*Publications.* The cost of publishing the reports has, during the last biennial period, consumed a considerable part of the appropriation. There was not sufficient, after doing the necessary field work, to publish one of the reports completed. There should be a specific allowance sufficient to cover this item. The value of the reports is in a measure lessened by tardiness in issuance.

*Library Cases and Furniture.* Owing to the small appropriation of the last few years we have not been able to add to the library, the volumes needed for reference in the preparation of our reports. The work of the Bureau would be assisted by the addition of much needed books. We

have several hundred volumes of unbound United States and foreign reports which should be bound.

The furnishings in the Bureau, which include carpets, cases, tables, chairs, etc., have been in use for fifteen years and are now nearly beyond the stage of repair. A small appropriation is needed for furnishing the offices, library and museum.

*In General.* The greatest efficiency can be secured by granting a sufficient appropriation to carry on, without hindrance or delay, the work, for which the Bureau was created.

*Estimates of Appropriation Needed for* 1905-6. To carry out the provisions of the law creating the Bureau of Geology and Mines, as outlined in Chapter 110 of the Revised Statutes of Missouri for 1899 and the Amendment thereto, passed by the 41st General Assembly, the Board of Managers consider it necessary that the following appropriation be made:

| | |
|---|---|
| For maintenance and support, including salaries and expenses of State Geologist, assistants and clerk | $27,000 |
| For supplies, equipment—including instruments used in the field—and apparatus for the chemical and physical laboratories | 5,000 |
| For topographic mapping in co-operation with the U. S. Geological Survey | 10,000 |
| For printing, engraving and preparing maps and other illustrations for reports | 7,000 |
| Total | $50,000 |

# CHAPTER V.

## THE MINERAL RESOURCES OF MISSOURI.

During the biennial period just past the output of the mines, quarries and clay working plants has kept pace with the developments in agriculture and the manufactures. Missouri still maintains her rank among the foremost mining states of the Union. She ranks first in the value of zinc and barite mined; second in the production of lead; seventh in the production of clay wares; sixth in the production of limestone; and twelfth in the production of coal. The value of the mining products for 1903 was nearly 30 millions of dollars distributed as follows:

| | |
|---|---|
| *Zinc | $6,790,214 |
| *Lead | 6,164,774 |
| **Coal | 6,913,444 |
| Barite | 102,822 |
| **Clay Products | 5,661,607 |
| Building Stone, Quicklime, Sand, Tripoli, etc. | 2,521,016 |
| Iron ore | 106,388 |
| Petroleum and Natural Gas (estimated) | 11,000 |
| Cement (Portland) (estimated) | 1,200,000 |
| | $29,471,265 |

*Lead and Zinc Mine Inspectors Report, 1903.
**Mineral Resources of the United States, U. S. Geological Survey, 1903.

Bulletin No. 9 of the publications of the Census Bureau reports that there were 1,045 operating and 32 partly developed mines and quarries in Missouri in 1903. In these mines and prospects there were 16,900 employees, receiving about $10,200,000 in salaries. There was paid for supplies and miscellaneous expenses $5,003,031. The total paid for wages and miscellaneous expenses was approximately $15,200,000. The value of the products considered in that report amounted to $20,284,655. Substracting the disbursements from the value of the product we have about $5,000,000, representing the addition made to the permanent wealth of the country through the production of the Missouri mines in 1902. In the total value of the mineral products for 1902, as reported by the Census Bureau, Missouri is eleventh among the states of the Union. She is exceeded in the total value of her mineral production only by, Pennsylvania, Ohio, Michigan, West Virginia, Colorado, Illinois, Montana, Indiana, California and Minnesota.

## ASPHALT AND ASPHALT ROCK.

The deposits of bituminous sandstone and limestone, referred to in the last biennial report as occurring in the western part of the state, have not yet been developed. At Liberal the bituminous (asphaltic) sandstone is quarried for sidewalks, curbing, etc., but up to the present time it has not been used for paving. Neither has any attempt been made to separate the asphalt from the rock.

The bituminous sandstone which occurs near Sheldon has been prospected sufficiently to show that it occurs over extensive areas. It has been tested sufficiently to warrant one in saying that it is of good quality. The percentage of bitumen or asphalt in the stone frequently reaches 12 to 15 per cent and there is every reason to believe that it constitutes a good material for making rock asphalt pavements. For more detailed information about the asphaltic sandstone near Sheldon the reader is referred to Chapter III., in which there is a report on lands in that locality.

## BARITE.

Barite, ($BaSO_4$), barium sulphate, is known by the miners and others as "ball tiff," "tiff," "heavy spar" and "spar." It occurs in many places throughout the Ozark region, chiefly associated with galena in the Cambro-Ordovician dolomites. The output in 1903, according to statistics gathered by this department, amounted to 26,069 tons, valued at $102,822.41. The only mines reporting an output for that year are located in Franklin, Washington, Jefferson and St. Francois counties. Miller, Morgan, Cole, Camden and Hickory counties have each produced barite in years past, but none of these reported an output for 1903.

The barite mines are shallow, seldom extending beyond the depths to which the clay seams can be followed. In many of the mines the barite occurs, associated with crystallized galena, known as "cog mineral," and is mined as a by-product.

Both the barite, and the galena with which it is associated, occur embedded in a tough, red clay, from which it is separated mainly by hand. The barite is graded roughly, according to the percentage of iron which it contains, into No. 1 and No. 2. The No. 1 barite is a clean, white product, while the No. 2 is stained a light reddish brown with iron oxide and clay. After leaving the discolored barite exposed to the rains for several months much of the iron oxide and clay are washed away. In this way the grade of the barite is frequently raised from No. 2 to No. 1.

During the last year "The Point Mining and Milling Company" has purchased 300 acres of barite land in Washington county and has erected a mill, at Mineral Point, in which the finest grade of floated barite is produced. The capacity of the mill is 25 tons of refined barite per day. The mill is situated in the center of the Barite region and should never lack for crude ore on which to run.

Barite mining in this state is carried on in a very desultory manner. The mines consist of hundreds of shallow shafts which are usually worked on a royalty. Some of these shafts are connected with drifts which have been worked and re-worked many times. Many of the farmers in the district work the shallow mines at odd times bringing the barite to market the same as they do wood.

The veins which occur in the undecomposed rock have scarcely been uncovered. These will some day supply the demand which is now met by the barite from the clay seams and the residual clay.

## BUILDING STONE.

During the last year, this department has published a comprehensive report descriptive of the quarrying industry of Missouri. This report includes a description of all the important quarries in the state; a treatise on the demands, uses and properties of stone; tables giving the strength of Missouri stone as compared with that from other well known quarries in the United States; and other valuable information relative to the demands and uses of stone. The following table, copied from page 326 of that report, gives the production of stone for Missouri in 1903, as obtained from reports furnished this department by the different operators.

TABLE NO. XII.

PRODUCTION OF STONE IN MISSOURI FOR 1903.

| | | |
|---|---|---|
| *Limestone.* | | |
| Rubble | 194,352 perch.... | $230,721 00 |
| Crushed | 1,115,872 cu. yds.. | *265,824 19 |
| Cut | 397,042 cu. ft.... | 265,991 97 |
| Rip Rap | 159,440 cu. yds.. | 138,658 44 |
| Miscellaneous uses | ..... | 129,963 59 |
| Quick Lime | 1,097,281 bbls..... | 422,781 82 |
| Total limestone products | ..... | $2,063,941 01 |
| *Granite.* | | |
| Crushed | 30,000 tons..... | †$30,000 00 |
| Monumental | 34,000 cu. ft.... | 26,175 00 |
| Spalls | 1,540 tons..... | 1,350 00 |
| Paving Blocks | 785,506 ..... | 19,870 00 |
| Curbing | 13,000 ft..... | 2,405 00 |
| Total | ..... | $79,800 00 |

*The railroads used 479,705 cu. yds. of crushed stone, valued at $239,852.50, the greater part of which is included in the returns received above.

†Incomplete returns.

| | | |
|---|---|---|
| ***Tripoli.*** | | |
| 75,000 filters<br>3,180 tons ground<br>900 tons crude | | $90,000 00 |
| ***Sand.*** | | |
| Glass and Moulding | 114,894 tons | †$59,163 00 |
| ***Sandstone.*** | | |
| Miscellaneous | | 34,423 17 |
| ***Chats.*** | | |
| Railroad Ballast | 407,378 cu. yds. | 203,689 00 |
| Other uses not estimated | | |
| Total production of quarry products | | $2,521,016 13 |

The United States Geological Survey report on the Mineral Resources gives the value of the output from the Missouri quarries in 1903 as $2,716,499.

†Incomplete returns.

In the southeastern part of the State, chiefly in Madison and Iron counties, there are extensive deposits of red granite. The stone from the granite quarries is suitable for all kinds of building constructions. It is hard, strong and durable. It takes a brilliant polish and is unsurpassed by few red granites for monuments and interior decorative purposes. When crushed, the granite makes an excellent material for macadam pavements or for use in concrete work. The curbing and paving blocks which are manufactured from this granite are more costly than limestone, sandstone and many of the foreign granites, but they are superior in strength and durability.

One of the most abundant stones in this state is limestone, the value of the product from which, exclusive of quicklime, amounted in 1903, to over $1,600,000. The limestone from many of the quarries is of excellent quality, specially suited for building purposes. The quarries at Carthage, Cape Girardeau, Hannibal, Phenix and Springfield contain some of the very best and most durable limestone in the United States.

The following table gives the results of tests made on the Carthage limestone as published on pages 131 and 132 of the report on "The Quarrying Industry."

Physical Tests.—Two inch cubes of limestone from Carthage were tested in the laboratory with the following results:*

*Material furnished by the Carthage Marble and White Lime Co.

| | | | |
|---|---|---|---|
| Specific Gravity | | 2.708 | |
| Porosity | | 1.244 | per cent. |
| Ratio of Absorption | | 0.502 | |
| Weight per cubic foot | | 167. | lbs. |
| Transverse Strength | | 2,285.5 | lbs. per sq. in. |
| | (a) | 14,270.6 | lbs. per sq. in. on bed. |
| | | 11,879. | lbs. per sq. in. on edge. |

| | | | |
|---|---|---|---|
| Crushing strength ..... | (b) | 16,337. | lbs. per sq. in. on bed. |
| | | 15,396. | lbs. per sq. in. on edge. |
| | (c) | 12,741.3 | lbs. per sq. in. on bed. |
| | | 12,684. | lbs. per sq. in. on edge. |
| | (d) | 17,777. | lbs. per sq. in. on bed. |
| Crushing strength of samples subjected to freezing test ..... | (a) | 13,332.7 | lbs. per sq. in. on bed. |
| | (b) | 15,865.0 | lbs. per sq. in. on bed. |
| | (c) | 13,921.0 | lbs. per sq. in. on bed. |

(a) Samples free from suture joints.
(b) Samples containing suture joints from ½ in. to ¾ in. in depth.
(c) Samples containing fine suture joints. Coarsely crystalline.
(d) Samples of free stone. Maximum crushing strength 20,261 lbs. per sq. in.

Three sets of specimens were used for determining the strength of the fresh and frozen samples, the results of which are given above. It will be observed that in the first case (a) the strength of the frozen samples was 887.9 pounds per square inch less than that of the fresh samples; in the second case (b) the frozen samples tested 472 pounds per square inch less than the fresh samples; and in the third case (c) the strength of the frozen samples was 1179.7 pounds more than that of the fresh samples. These tests were made upon stone which was free from suture joints and on pieces containing suture joints. The results seem to indicate that the stone suffers comparatively little injury from alternate freezing and thawing.

The slight difference between the ultimate strength of this stone on bed and on edge, as shown in all three cases, proves conclusively that there is no danger from placing the stone on edge in constructional work.

The weight of the stone as computed from the specific gravity and porosity determinations is somewhat lower than the weight of the stone as it comes from the quarry. A block containing about one cubic foot of stone, tested in the office of the Carthage Marble and White Lime Company, weighed 170 pounds. This, for commercial purposes, may be taken as the weight of the stone.

The manufacture of quicklime is one of the important industries in Missouri and for this purpose the Burlington and Trenton limestones are unexcelled. The quicklime industry will be the subject of a special report to be issued by this Bureau sometime during the next two years. In this report the distribution of limestone suitable for the manufacture of quicklime will be considered, as well as the qualities of the different quicklimes produced from the limestone from the different formations. The importance of this industry in Missouri is shown by the output, which, in 1903 was valued at nearly a half million dollars.

The sandstone quarries in this state are, with two or three exceptions, small, and the product is used chiefly for local consumption. The

quarries at Warrensburg and Miami are large and the stone is valuable both for building purposes and for the manufacture of grindstones. The stone from these quarries finds a ready market in the southern states, to which most of the product is now being shipped. The yellow and brown colored sandstones which occur throughout the Ozark region are strong and durable. They constitute a very desirable material for sidewalks, crosswalks, curbing and foundations. As far as strength and durability are concerned, they are desirable building stones, but their color is seldom uniform and therefore not desirable for buildings.

The St. Peters sandstone which is known as the Saccharoidal, Crystal City and Pacific, is in many places almost pure silicon dioxide. It is soft and friable and can often be broken down with a pick and shovel. It occurs in unlimited quantities near Pacific, where three companies are working quarries from which each ships in the neighborhood of three car loads of sand per day, most of which is used in the manufacture of glass. The Pittsburg Plate Glass Co., at Valley Park is using three car loads of this sand per day. It is reported by those experienced in glass making, that this is superior to any sand which is being quarried in the United States. Sand of as good quality occurs in unlimited quantities at Klondike and Crystal City, at each of which places it is extensively quarried.

Sand is one of the very necessary materials used in all kinds of masonry construction. It is obtained from sandstone quarries, from banks along rivers and streams, from lake shores, from glacial deposits, from sand dunes, and from vein quartz and quartzite by crushing. It is difficult to estimate the quantity of sand used in this state. As a rule none but the largest companies keep a record of their sales. The estimate of approximately $60,000 for sand in the manufacture of glass and for moulding, is very low. The probability is that these figures should be doubled.

The U. S. Geological survey report on the "Mineral Resources" gives the value of sand used in Missouri in 1903, for glass making, engine and furnace uses and for building, as $128,036.

## CHAT.

The tailings which result from the concentrating of the blende and galena mined in the southeastern and southwestern parts of this state, are commonly known as chat. This chat is now being used in great quantities by the railroads for ballast and in the construction of concrete piers, abutments in bridges and culverts It is also used extensively in cement curbs and gutters. This chat consists chiefly of crushed flint and

limestone and thousands of tons of this material may be had in Jasper, St Francois and Lawrence counties.

It is thought that the chat might be used in the manufacture of artificial stone, electrical conduits and sewer pipes.

### CLAY PRODUCTS.

According to statistics published in the U. S. Geological Survey report on "The Mineral Resources," Missouri ranks seventh among the states in the value of her clay products in 1903. Our records show that in 1903 there were approximately 250 factories in this state manufacturing brick, tile, terra cotta, sewer pipe, pottery, fire proofing and other clay products. The following is a summary of the value of the clay products manufactured in this state in 1903 as given in the U. S. Geological Survey report referred to above.

| | |
|---|---|
| Common Brick | 1,725,253 |
| Front Brick | 333,965 |
| Vitrified Paving Brick | 307,965 |
| Ornamental Brick | 39,756 |
| Fire Brick | 925,915 |
| Drain Tile | 45,363 |
| Sewer Pipe | 1,050,794 |
| Ornamental Terra Cotta | 371,006 |
| Fire Proofing | 91,538 |
| Hollow Building Tile or Blocks | 7,355 |
| Tile (not drain) | 235,091 |
| Miscellaneous | 409,355 |
| Pottery | 51,401 |
| Total | 5,661,607 |

The above report shows an increase in the value of clay products since 1901 of over $1,000,000.

Brick, tile, terra cotta, cement and stone are the building materials of the future. The supply of raw materials in Missouri, for the manufacture of clay products, is unlimited and as the demand for these products increases, there will be a proportionate development of the clay industry. At the present time the value of these products in this state is only exceeded by those of lead and zinc.

The search for clay deposits suited for the manufacture of the great variety of clay products now in use, is constantly going on. We receive at this office, many inquiries relative to the location of clays suitable for the manufacture of different kinds of clay wares. Many samples of clay are received for examination and as rapidly as possible we are assuming a position where we can be of service to the state in pointing out to prospective manufactures the location of desirable clay deposits. The abundance and variety of clays in this state, are surpassed by few if any in the Union. The proximity of the clay banks to coal

mines, the nearness to the markets and the excellence of shipping facilities make the possibilities of the industry in this state very great.

Ohio, New York, Iowa and Wisconsin have laboratories equipped for testing both clays and clay products. It is equally as desirable and important that this state should provide a similar laboratory. The experimental work required is in line with the investigations carried on by this Bureau and it is hoped that an appropriation may be made to equip and maintain a laboratory for this purpose.

## COAL.

Missouri ranks twelfth among the coal producing states. The report on the Mineral Resources of the United States, published by the United States Geological Survey, gives the output of coal in Missouri for 1903 as 4,303,332 short tons valued at $6,913,444. The coal is chiefly bituminous and is used mainly for steam and household purposes. According to Bulletin No. 9 of the Census Bureau there were 384 corporations and individuals engaged in mining coal in this state in 1902. One company produces one-fourth of the total output while over one-half of the total output is produced by ten companies. The counties producing over 100,000 short tons, in order of their importance, are Macon, Lafayette, Randolph, Bates, Adair, Ray, Vernon, Barton and Putnam.

The approximate surficial distribution of the Pennsylvanian series, which includes all the Coal Measures strata, is shown on the general geological map, which accompanies this report. Winslow estimated the maximum thickness of the Pennsylvanian at 1900 feet in the northwestern part of the state. The dip to the west and northwest has been estimated at aproximately ten feet to the mile.

The Pennsylvaniaan, (Upper Carboniferous) is subdivided into either two or three groups, either Missourian (Lower) and Des Moines (Upper), or Lower, Middle and Upper. The series as a whole consists of beds of shale, sandstone and limestone. The lower beds are chiefly shale and sandstone, the middle contain some limestone of a shaly nature, while the upper beds are chiefly limestone. The limestone gradually increases in importance towards the top of the series.

Mr. B. F. Bush, in a paper read before the American Institute of Mining Engineers, states that there are a total of twenty-nine seams or coal horizons recognized from the base to the top of the Pennsylvanian series in this state. The most important seams occur in the middle beds and from these a greater part of the coal in Missouri is mined. The seams in the Upper Coal Measures (Des Moines) are very thin and have only been worked in a small way in Nodaway and Atchison counties.

Up to the present time coal mines have not been opened at any considerable distance from the railroads, transportation facilities being very essential to their profitable development. There are thousands of acres of land which remain unprospected and from which the future coal production of this state will be obtained.

During the last year the Rich Hill area has been practically abandoned, the ground having been reported as being worked out. At the same time a new field has been opened up to the west and southwest, in the neighborhood of Sprague. Drill holes in the vicinity of Stotesburg and elsewhere show a very good vein of coal at a moderate depth.

Considerable interest has been manifested in the deposits of coal in Morgan, Moniteau and Miller counties. The deposits in these counties are, in some instances, of phenomenal thickness but they usually occupy a depression in the underlying limestone formations, on account of which they do not persist over very large areas. The coal in these pockets is both bituminous and cannel, usually of good quality. Several of these coal pockets are being developed on quite a large scale. To the Simpson Coal bank, in Moniteau county, now owned by the Monarch Coal and Mineral Company, the Chicago, Rock Island, and Pacific Railroad is building a spur about seven miles long.

## COPPER.

For many years copper has been known to occur at a great many localities throughout the Ozark region, chiefly associated with the deposits of brown iron ore. In 1848 and '49, copper was mined at a place called Copper Hill in Crawford county. Mines were also opened up at an early date in Ste. Genevieve county and prospecting has been carried on near Eminence in Shannon county. None of the deposits are very large, although some of them are comparatively rich.

The most active developments in this State, have been carried on by the Copper Mountain Mining Company, at their mines in Crawford county about four miles southeast of Sullivan. This company is working a deposit of carbonate and sulphide ores which is reported to have been mined for copper in 1848 and '49. The company has a concentrating mill and smelting plant at the mine and is preparing to handle the ore in the most economical manner.

It is difficult to predict the size of this deposit, although the shafts which have been sunk and the drifts which have been run, indicate that the deposit is sufficiently large to run a small matte furnace for some time.

A copper deposit occurs near Ste. Genevieve, which is evidently of some importance. Although it is not being developed at this time, it

will probably be exploited as soon as the market for copper is favorable.

Another deposit of copper ore occurs in Shannon county. The extent of this deposit can only be determined by drilling the land adjacent to the ores which are now exposed. It is possible that a workable deposit of copper occurs at this locality.

There is reported to be a good seam of copper ore at the old copper mine on the Mine La Motte estate. Up to the present time very little work has been done at this place. Under favorable conditions, the copper and the lead with which it is associated, might be exploited with profit.

There are a great many deposits of mixed corbonate and sulphide copper ores associated with the iron ore banks throughout the Ozark region. Some of these deposits may be of workable size, although thus far they have not been developed sufficiently to warrant expressing an opinion as to their value.

## IRON ORES.

During 1903 there were twenty-five to thirty different companies and individuals mining or opening up banks of iron ore in this state. From reports furnished this Bureau the output for 1903 is shown to be 51,541 short tons valued at $106,388 47. The output of a number of the mines was not reported, on account of which this figure is an underestimate.

Two furnaces were operated in the state in 1903, one by "The St. Louis Blast Furnace Co.," at Carondolet, and the other by "The Sligo Furnace Co.," at Sligo. The St. Louis Blast Furnace Co. received approximately 31,500 tons of ore from Iron Mountain, obtained chiefly from the old dumps which they have been cleaning up. They also received about 19,500 tons of brown hematite from various other localities in the State. The Sligo Furnace Co., purchased their own ores, chiefly from the Lake Superior district. Only a small tonnage was purchased from Missouri mines. At present this company is operating mines at Cherry Valley and Steelville and these mines, with an average output of about 200 to 250 tons per day, furnish all the ore which they use.

The iron mines that are being worked are all located in the area underlain with Cambro-Ordovician or pre-Cambrian rocks. Franklin, Maries, Crawford, Phelps, Dent, Iron, Howell, Shannon, Carter, Ripley and Butler counties have been the principal producers. The deposits in Greene and Christian counties have been under investigation and a company has been organized to exploit them.

The iron ores of the Ozark region are chiefly soft red, hard red and blue specular hematite, although relatively large deposits of limonite or brown hematite occur associated with the dolomite and chert. The red and specular hematites are usually associated with the sandstone formations.

There is no evidence that the bodies of iron ore in this state are anywhere comparable in size with the deposits of the Lake Superior region. There are, however, numerous deposits of both red and brown hematite, of excellent quality, which are large enough to justify exploitation on a small scale. It is anticipated that during the next few years the output will be greater than it has been for several years.

## LEAD AND ZINC.

The only producing lead and zinc mines in this state are located south of the Missouri river. The mines of Jasper, Newton and Lawrence counties in the southern part of the State and those of St. Francois and Madison counties in the southeastern part, are the chief producers.

**Output.* During the year 1903 the lead mined in Missouri, sold for $6,212,051. With the exception of 1,438,000 pounds of cerrussite (lead carbonate), known to the miners as "dry bone," and a few hand specimens of anglesite (lead sulphate), the lead was in the form of galena. The average selling price of the galena in the western district, (Joplin district), was $52.69 per ton, and in the eastern district, (St. Francois and Madison counties), $46.81 per ton. The average selling price of the cerrussite, all of which was mined in the western district, was $34 80 per ton.

The value of the zinc ores mined in Missouri in 1903, was $6,790,214, of which Jasper county alone produced $5,877,261. The ore is chiefly sphalerite, known commonly as blende or jack, and calamine known to the miners as silicate. The total output of silicate for 1903, was valued at $263,056 77. The average price of the sphalerite in the western district in 1903 was $33.27 per ton, while in the eastern district it sold at an average of $37.93 per ton. The silicate in the western district sold at an average of $19.80 per ton, while that from the eastern district sold at an average of $13.43 per ton.

**Extent of Mining.* In the western district, there were 7,693 men engaged in mining and prospecting for lead and zinc ores in 1903. In the eastern district, in 1903, there were 4,682 men engaged in mining, chiefly lead and zinc. The total capitalization of the

*Figures from the report of the Lead and Zinc Mine Inspectors for 1903.

companies engaged in mining these ores in Missouri, is over $57,000,000.

Compared with the other states in the union, Missouri ranks first in the production of zinc, and second in the value of her lead production. In 1904 the Joplin district is reported to have produced lead and zinc ores valued at $11,695,873, which is greater than the total production of gold in Alaska in 1903.

*Distribution of Mines.* According to the report of the Lead and Zinc Mine Inspectors there were twenty-two counties in the state producing lead and zinc in 1903, while there are several other counties which are known to have mines capable of producing one or both of these ores in commercial quantities. The counties reporting a production of one or both of these minerals in 1903, are Barry, Benton, Christian, Dade, Greene, Hickory, Jasper, Lawrence and Newton in the western districts; and Camden, Cole, Crawford, Franklin, Jefferson, Madison, Miller, Moniteau, Morgan, Ozark, St. Francis, Washington and Wright counties in the eastern district. The value of the combined output of lead and zinc as given in the Mine Inspectors report for 1903 for each of these counties is shown in the following table. The counties are arranged in the order of greatest production.

| | |
|---|---|
| Jasper | $6,990,052 |
| St. Francois | 4,309,501 |
| Newton | 543,157 |
| Lawrence | 389,790 |
| Madison | 329,172 |
| Washington | 117,517 |
| Jefferson | 64,996 |
| Franklin | 59,236 |
| Greene | 49,199 |
| Moniteau | 41,966 |
| Ozark | 10,300 |
| Benton | 9,996 |
| Crawford | 9,231 |
| Dade | 5,980 |
| Morgan | 5,130 |
| Cole | 2,982 |
| Camden | 2,592 |
| Barry | 1,973 |
| Wright | 1,911 |
| Christian | 1,827 |
| Miller | 1,500 |
| Hickory | 1,260 |
| | $13,226,168 |

*Permanent Character of the Lead and zinc Mining.* Some people have evidently obtained a very erroneous impression as to the future of lead and zinc mining in this State and especially in the western or Joplin district. It is frequently reported,—sometimes in the columns of

our leading mining journals,—that the opening up of mines in new ore bodies is not keeping pace with the abandonment of mines already developed. It is true that the production, in tons, of ore for 1903 was less than for the preceding year. In the Joplin district such a result is not surprising to one who knows the nature of the district or to one who is familiar with the lead and zinc markets. The operators have intentionally curtailed the output at times in order to force up the market. Then there has been less advertising of the district on the part of the people interested. For these reasons the output or development has not kept up with the demand. But to reason from this that the paying ore bodies have all been discovered is very absurd. The truth is that mining has been placed upon a substantial business basis in the Joplin district. A careful examination of the Southwestern part of the State clearly indicates that there still remains a vast field for legitimate prospecting with promise of rich returns. Between the cities of Carthage, Aurora, Granby and Neck City and west to the Kansas line, there are thousands of acres of promising land which has not been prospected.

Mining in the "Disseminated Lead District," in St. Francois and Madison counties, remains steady and there is very little speculation on the part of the public as to the permanence of the ore bodies in this district. There has been some change in the management of the mines both in Madison and St. Francois counties, but the developments have gone on with practically no curtailment of the output.

In Washington, Franklin and Jefferson counties, the mines are small and the ore is obtained chiefly from the residual clay and flint at the surface or from seams in the rock. The output is chiefly galena and barite, which occur associated together.

There have been very few developments in what is known as the Central Lead and Zinc District. In Moniteau county one mine is being operated near Fortuna. The output from this mine has been comparatively steady, although the conditions do not warrant one in anticipating an increase in the output in the future. Some prospecting has been done in Miller, Cole, Morgan and Camden counties, but up to the present time no large lead or zinc mines have been developed.

Prospectors in counties adjacent to Jasper, including Dade, Lawrence, Greene, Newton and Barry, have met with some encouragement. Profitable deposits of lead-zinc ore, other than those already developed, will probably be found in the area covered by these counties.

### MINERAL PAINTS.

Missouri produces small quantities of paint pigments, other than lead, zinc, barite and kaolin. The soft red hematite, some of which is

argillaceous and very finely pulverized, is sold chiefly as a paint pigment. Small deposits of very ferruginous clay, classed as umber and sienna are exploited on a small scale, but the output is not known.

### MINERAL WATERS.

One of the most attractive resources of any state is an abundant supply of pure drinking water. Pure spring waters, charged with mineral salts, located amidst pleasant surroundings, attract thousands of tourists to any state. The entire State of Missouri is dotted with springs, hundreds of which, on account of their mineral content, must be classed as mineral springs. During 1902, there were eighteen mineral springs reported to the U. S. Geological Survey, as marketing mineral water. During that year, the value of the mineral water sold, amounted to $204,270.

Compared with the number of mineral springs in the State and the quality of the waters which they supply, the amount of revenue derived therefrom, is very small. This industry might be very greatly developed.

This Bureau is desirous of obtaining the location of all mineral springs within the State. It is our wish to be of assistance in making these valuable mineral springs better known among the people.

### NICKEL AND COBALT.

The entire output of nickel and cobalt in this State comes from the mines near Fredericktown, in Madison county. The Mine LaMotte Lead and Smelting Company reported having on hand December 31, 1903, $276,400.00 worth of nickel, cobalt and copper matte.* Up to this time no metal or oxide has been produced. The company has a plant, consisting of roasters, smelters and refinery, for treating nickel and cobalt sulphide ores.

The North American Lead Company produced about ten car loads of nickel and cobalt sulphides during 1903.

The Catherine Mine has heretofore reported a small output of nickel and cobalt sulphides, but evidently there were none mined in 1903.

### PETROLEUM AND GAS.

Prospecting for petroleum and gas during the last two years has been quite general in the western and northwestern parts of the State. The results, however, have not been very encouraging. The close proximity of the Kansas petroleum and gas field and the nearness of a very

*See Lead and Zinc Mine Inspector's report, Mo., 1903, p. 263.

excellent market, have combined to induce more prospecting than would probably, otherwise, have been indulged in.

Small quantities of both petroleum and gas have been found in many of the wells where the formation known as the Cherokee has been passed through. Wells which indicate that either petroleum or gas can be obtained in Western Missouri in commercial quantities are confined to two localities,—Belton, Cass county, and Kearney, in Clay county. At Belton there are now seven producing oil wells.

There is an extensive area in Northwestern Missouri, underlain with Pennsylvanian limestone, shale and sandstone, which has been prospected very little. Conditions favorable to the production, storage and retention of both petroleum and gas may exist in this part of the State. The structure of this area has never been carefully worked out and until that has been done one cannot, with any degree of certainty, express an opinion as to the probable occurrence of petroleum and gas. The reconnaissance work by the early geologists, published in the reports of 1872 and 1873, gives very meager information as to the folding and flexuring of the beds, although folds were recognized and incidentally referred to.

In 1903 the Welle-Boettles Bakery Company of St. Louis struck natural gas in a well which they drilled at their plant on Vandeventer avenue and Forest Park boulevard. The gas was struck at a depth of 670 feet and is reported to have furnished a pressure of 250 pounds. Since then two additional wells have been sunk, from one of which gas was obtained. The second well was sunk to a depth of 1,000 feet without encountering anything but salt water. In the third well traces of oil were found at a depth of 280 feet and gas at 675 feet.

The gas from the first well has been used to heat three furnaces, or six ovens, day and night.

There is very little probability of encountering either gas or petroleum in large amounts in the small basin of Carboniferous rocks, upon which St. Louis is located. Other wells of small pressure may be found but the structure of the region combined with the restricted nature of the basin argues against finding either petroleum or gas in large quantities.

The value of petroleum and gas production in 1903 has been estimated at about $11,000.

## PORTLAND CEMENT.

During 1903 two companies have been manufacturing Portland cement in this State, viz.: the Atlas Cement Company, at Hannibal, and the St. Louis Portland Cement Company at Prospect Hill, just north of

St. Louis. The Atlas plant when completed will have a capacity of 7,000 barrels per day while the plant of the St. Louis company has a capacity of 1,500 barrels per day. A third plant is in process of construction at Louisiana, and when completed will have a capacity of 5,000 barrels per day.

There are almost unlimited possibilities in the manufacture of Portland cement in this State. Raw materials in the shape of limestone and shale occur abundantly in the eastern and western parts. The Burlington, Trenton and, in some places, the Upper Coal Measures, contain very pure limestone, while the Hannibal, Hudson River, Hamilton and Coal Measure formations contain, in many places, high grade shales. Wherever shale and limestone occurring together are of such a composition that one can obtain easily, by mixture, silica, alumina and calcium carbonate in about the proportions of 58% to 64% $CaCO^3$ (lime) 18% to 24% $SiO_2$ (silica) and 8% to 14% $Al_2O_3$ (Alumina), Portland cement can be manufactured. However, in order to make the manufacture of Portland cement successful one must also consider the cheapness of suitable fuel, the facilities for transportation and the markets.

The Portland cement manufactured in Missouri, in 1903, was valued at $1,164,834, according to the report of the U. S. Geological Survey on "The Mineral Resources of the United States."

PYRITE.

Attention is called to the market which is being created for sulphuric acid by the erection of the oil refineries at Kansas City and in the Beaumont district. These refineries consume great quantities of sulphuric acid which must be supplied by nearby plants. The sulphuric derived from the decomposition of the sulphide minerals is also in demand for the manufacture of sulphuric acid used in the manufacture of fertilizers.

The sulphur dioxide required for the manufacture of sulphuric acid is contained in any sulphide mineral,—blende, galena and pyrite being the most common sources.

Some method should be devised by which the 24 per cent of sulphur thrown into the air during the process of roasting and smelting the lead ores in this State, could be converted into sulphuric acid. In St. Francois county alone, it is estimated that 62,000 short tons of sulphur are expelled from the furnaces each year. This quantity of sulphur would make about 240,000 tons of sulphuric acid.

There are deposits of pyrite or marcasite (iron sulphide) associated with the iron banks which are scattered over the Ozark table-land but many of them are too far from the railroads to be of commercial value.

Associated with the lead ores in Washington and neighboring counties there are considerable quantities of marcasite, which, except for want of transportation facilities, would be valuable for the manufacture of sulphuric acid.

A good grade of iron sulphide, either pyrite or marcasite, is worth $5.00 a ton.

### TRIPOLI.

The output of tripoli in Missouri comes chiefly from Seneca, Newton county. The deposits at this place are very large and exceptionally pure. There are three companies operating in this field, the product being used in the manufacture of filters, as an abrasive and in the manufacture of polishing paste and dynamite. The output in 1903 was valued at approximately $90,000.

The tripoli at this place is a decomposed chert or flint of Mississippian age. The deposits vary in thickness from 2 to 20 feet.

# FINANCIAL STATEMENT

**Showing the Expenditures of the Bureau of Geology and Mines January 1, 1903, to December 31, 1904.**

**(Furnished by the State Auditor.)**

**1903.**

| Date. | To Whom Paid. | Amount. | |
|---|---|---|---|
| April 21... | D. K. Gregor | $100 00 | Provid'd for in defic'ny bill 1903. |
| | G. A. Fisher | 1 10 | |
| | E. R. Buckley | 945 28 | |
| | H. A. Buehler | 199 54 | |
| | A. F. Smith | 128 60 | |
| | Jesse Parker | 54 00 | |
| | Lena Strobach | 75 00 | |
| | A. S. Whitehead | 24 00 | |
| | H. F. Johnson | 17 50 | |
| | H. H. Gregg | 22 00 | |
| | E. M. Shepherd | 58 60 | |
| 22... | E. Long | 50 00 | |
| May 7.... | E. R. Buckley | 341 96 | |
| | A. F. Smith | 100 00 | |
| | Lena Strobach | 35 00 | |
| | Jesse Parker | 18 00 | |
| | A. Heinberger | 25 25 | |
| | H. T. Johnson | 7 25 | |
| May 12.... | H. A. Buehler | 100 00 | |
| 27.... | E. B. Craighead | 17 20 | |
| | E. M. Shepherd | 54 20 | |
| June 4..... | E. R. Buckley | 354 70 | |
| | Lena Strobach | 35 00 | |
| | A. F. Smith | 222 08 | |
| | H. A. Buehler | 120 23 | |
| | H. A. Rossler | 7 00 | |
| 9..... | Tribune Printing Company | 51 06 | |
| 12.... | Jesse Parker | 18 00 | |
| | H. H. Gregg | 19 00 | |
| July 6.... | E. R. Buckley | 320 02 | |
| | Lena Strobach | 35 00 | |
| | Jesse Parker | 18 00 | |
| | H. A. Buehler | 100 00 | |
| | F. B. Van Horn | 90 95 | |
| | E. B. Hall | 16 50 | |

1903—Continued.

| Date. | To Whom Paid. | Amount. |
|---|---|---|
| Dec. 5.... | A. F. Smith | $110 61 |
| | F. M. Harper | 21 00 |
| 13.... | Bicklel Marble and Granite Company | 97 20 |
| 22.... | W. D. Jones | 55 00 |
| Aug. 4.... | H. A. Buehler | $100 00 |
| | Lena Strobach | 35 00 |
| | F. W. Harper | 21 00 |
| | Jesse Parker | 18 00 |
| | E. R. Buckley | 319 21 |
| | E. B. Hall | 65 98 |
| | A. F. Smith | 152 60 |
| | F. B. Van Horn | 159 75 |
| 14.... | E. B. Craighead | 24 10 |
| 24.... | H. H. Gregg | 10 00 |
| Sept. 3.... | Lena Strobach | 35 00 |
| | H. A. Buehler | 100 00 |
| | E. R. Buckley | 332 11 |
| | A. F. Smith | 165 82 |
| | F. W. Harper | 21 00 |
| | Jesse Parker | 11 00 |
| 8.... | F. B. Van Horn | 142 00 |
| | E. B. Hall | 35 00 |
| Oct. 3.... | E. R. Buckley | 276 07 |
| | A. F. Smith | 157 85 |
| | F. B. Van Horn | 153 97 |
| | C. F. Marbut | 147 20 |
| | H. A. Buehler | 106 55 |
| | E. B. Hall | 58 50 |
| | Otto Vaetch | 39 55 |
| | Lena Strobach | 35 00 |
| | Jesse Parker | 21 00 |
| | D. F. Higgins | 11 50 |
| | F. W. Harper | 7 00 |
| 30.... | Otto Vaetch | 25 50 |
| Nov. 3.... | E. R. Buckley | 286 70 |
| | H. A. Buehler | 116 55 |
| | E. B. Hall | 43 40 |
| | Lena Strobach | 35 00 |
| | Jesse Parker | 21 00 |
| 4.... | A. F. Smith | 153 37 |
| 7... | F. B. Van Horn | 124 10 |
| 19.... | D. C. Hardy | 33 00 |

1903—Continued—.

| Date. | To whom paid. | Amount | |
|---|---|---|---|
| Dec. 5.... | E. R. Buckley | 354 34 | |
| | H. A. Buehler | 161 56 | |
| | Jesse Parker | 21 00 | |
| | F. B. Van Horn | 60 00 | |
| | A. F. Smith | 162 60 | |
| | Lena Strobach | 35 00 | |
| | Mound City Eng. Co | 164 18 | |
| 8.... | E. B. Craighead | 7 55 | |
| 9.... | Library Bureau | 55 09 | |
| | H. H. Gregg | 19 50 | |
| 11.... | E. M. Shepherd | 30 15 | |
| | Total | | $8,730 66 |

1904.

| Date. | To whom paid. | Amount | |
|---|---|---|---|
| Jan. 8.... | Tribune Printing Co. | $13 60 | |
| Jan. 9.... | E. R. Buckley | 337 56 | |
| | A. F. Smith | 151 30 | |
| | Jesse Parker | 21 00 | |
| | F. B. Van Horn | 60 00 | |
| | H. A. Buehler | 112 15 | |
| | Lena Strobach | 35 00 | |
| | W. J. Lloyd | 154 71 | |
| Jan. 11.... | E. B. Craighead | 13 10 | |
| Feb. 5.... | E. R. Buckley | 125 00 | |
| | Lena Strobach | 35 00 | |
| | S. C. Brickley | 21 00 | |
| | A. F. Smith | 151 60 | |
| | D. F. Higgins | 5 50 | |
| | F. B. Van Horn | 60 00 | |
| Feb. 11.... | H. A. Buehler | 100 00 | |
| 18.... | H. A. Buehler | 27 93 | |
| Mch. 3.... | E. R. Buckley | 272 35 | |
| | Lena Strobach | 35 00 | |
| | H. A. Buehler | 151 85 | |
| | S. C. Brickley | 21 00 | |
| | F. B. Van Horn | 60 00 | |
| | L. G. Lehman | 24 20 | |

1904—Continued.

| Date. | To whom paid. | Amount |
|---|---|---|
| Mch. 4.... | A. F. Smith | 148 25 |
| 14.... | Oscar Andreen | 28 00 |
| 16.... | Tribune Printing Co. | 605 04 |
| 17.... | E. B. Craighead | 15 65 |
| | H. H. Gregg | 46 65 |
| April 2.... | E. R. Buckley | 308 78 |
| | S. C. Brickley | 21 00 |
| | Lena Strobach | 35 00 |
| | H. A. Buehler | 100 00 |
| | L. G. Lehman | 12 00 |
| | F. B. Van Horn | 86 75 |
| | A. T. Smith | 136 35 |
| 8.... | E. B. Craighead | 20 60 |
| 12.... | E. M. Shepherd | 42 25 |
| 19.... | Mound City Engraving Co. | 480 00 |
| 27.... | Tribune Printing Co. | 8 56 |
| May 3.... | E. R. Buckley | 379 61 |
| | H. A. Buehler | 154 49 |
| | A. F. Smith | 142 95 |
| | F. B. Van Horn | 71 25 |
| | L. G. Lehman | 8 92 |
| | Lena Strobach | 35 00 |
| | S. C. Brickley | 21 00 |
| June 13.... | E. R. Buckley | 333 15 |
| | H. A. Buehler | 20 90 |
| | A. F. Smith | 149 75 |
| | L. F. Putnam | 16 25 |
| | Lena Strobach | 35 00 |
| | F. B. Van Horn | 60 00 |
| | S. C. Brickley | 21 00 |
| 17.... | H. A. Buehler | 100 00 |
| July 6.... | E. R. Buckley | 323 70 |
| | F. B. Van Horn | 83 30 |
| | A. F. Smith | 151 29 |
| | Lena Strobach | 35 00 |
| Aug. 4.... | Mound City Engraving Co | 231 90 |
| | H. A. Buehrle | 100 00 |
| | F. B. Van Horn | 63 25 |
| | Lena Strobach | 35 00 |
| | Ralph Bailey | 14 00 |
| | A. F. Smith | 145 96 |

1904—Continued.

| Date. | To whom paid. | Amount | |
|---|---|---|---|
| | E. R. Buckley | 302 79 | |
| 9.... | E. B. Craighead | 25 80 | |
| 16.... | Oscar Andreen | 270 00 | |
| Sept. 3.... | E. B. Craighead | 11 75 | |
| | Ralph Bailey | 14 00 | |
| | E. R. Buckley | 255 40 | |
| | Lena Strobach | 35 00 | |
| | H. A. Buehler | 100 00 | |
| | A. F. Smith | 152 55 | |
| | F. B. Van Horn | 60 00 | |
| 13.... | H. H. Gregg | 18 10 | |
| 29.... | Tribune Printing Co | 1,247 53 | |
| Oct. 7.... | H. A. Buehler | 100 00 | |
| | Ralph Bailey | 14 00 | |
| | E. R. Buckley | 260 00 | |
| | Lena Strobach | 35 00 | |
| | F. B. Van Horn | 60 00 | |
| | Aug. Gast Bank Note Co | 127 00 | |
| | A. F. Smith | 100 00 | |
| 10.... | E. R. Buckley | 82 51 | |
| 18.... | Aug. Gast Bank Note Co | 381 50 | |
| Nov. 7.... | E. R. Buckley | 358 79 | |
| | H. A. Buehler | 100 00 | |
| | F. B. Van Horn | 4 00 | |
| | A. F. Smith | 100 00 | |
| | Lena Strobach | 35 00 | |
| | Ralph Bailey | 14 00 | |
| Dec. 2.... | E. R. Buckley | 260 00 | |
| | Lena Strobach | 35 00 | |
| 9.... | E. R. Buckley | 7 89 | |
| | Total | | $11,371 04 |

MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

# BIENNIAL REPORT

OF THE

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# STATE GEOLOGIST

TRANSMITTED BY THE

## BOARD OF MANAGERS

OF THE

## BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fourth General Assembly

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JEFFERSON CITY, MO.

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MISSOURI BUREAU OF GEOLOGY AND MINES.
ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

BIENNIAL REPORT
1905-06

OF THE

# STATE GEOLOGIST

TRANSMITTED BY THE

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OF THE

## BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fourth General Assembly

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Library
University of [illegible]
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Hon. Elias S. Gatch, Vice-President.....St. Louis
Hon. Stonewall Pritchett, Secretary.....Webb City
Prof. Edward M. Shepard, Sc. D.....Springfield
Hon. L. F. Cottey.....Edina

# PREFATORY LETTER.

Bureau of Geology and Mines,
Rolla, Mo., Dec. 31, 1906.

To the President, Governor Joseph W. Folk, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines for the years 1905 and 1906, as required by law. This report contains, first, a review of the work of the Bureau for the biennial period; second a statement of the expenditures of the Bureau; third, a statement of the needs of the Bureau with recommendations for its increased efficiency; fourth, a summary of mining developments during the biennial period.

The importance of the investigations of this Bureau cannot be estimated from the brief summary contained in these pages. They express very inadequately the influence which this department exerts on the industrial development of the commonwealth. Our investigations reach, not only lead, zinc and coal mining, but also quarrying, cement manufacturing, the exploitation of sand and gravel, materials used in highway improvements, the manufacture of cement, the manufacture of lime, and many other fields. Our reports are sent to all parts of the globe, and through this distribution the mineral resources of the state are becoming more widely and better know.

Whatever of success may have attended our work, is in a large measure, the result of the interest which you, the members of the Board of Managers, have taken in the Bureau. The citizens of the State have, uniformly, welcomed our presence in their midst and through their kindly appreciation of our services we cannot but anticipate an increasing usefulness for the Bureau in the future.

Your obedient sir,

E. R. BUCKLEY,
Director and State Geologist.

# STAFF OF THE BUREAU OF GEOLOGY AND MINES.

Ernest Robertson Buckley, Ph. D....Director and State Geologist
Henry A. Buehler, B. S.....Assistant State Geologist
Guy W. Crane .....Assistant Geologist
Miss Lena J. Strobach .....Clerk and Stenographer

In addition to the above there have been several temporary employes, none for a longer period than six months. Among these were Messrs. R. H. DeWaters and B. J. Snyder, who assisted in the chemical laboratory; and Messrs. C. C. Baker and F. Grant Cooke, who have assisted in the drafting.

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# CHAPTER I.

## EMPLOYES, EQUIPMENT AND PUBLICATIONS OF THE BUREAU.

During the past biennial period there have been few changes in the staff. Our appropriation has not been sufficient to increase the number of employes, as a result of which the requests for our services, in some parts of the State, have been answered only by correspondence. It has been our purpose to carry the investigations of the mineral resources into all sections of the State, irrespective of their present importance, and should any portion seem to have been neglected, it may be attribued to the small number of employes which it is possible to support with the present appropriation.

In the employment of assistants it has been our purpose to select men who have had experience and whose training has been such as to especially fit them for the investigations required by this department. This Bureau is not a training school for students, and its value and efficiency must depend upon the employment of those who are able to carry on original investigations without the constant supervision of the Director.

Your attention is also called to the importance of continuous service on the part of the employes of a scientific bureau of this character. The value of the services of an employe in this Bureau increases with his knowledge of the geology of the State. The first year or two he becomes familiar with geological conditions in the State and may develop into a valuable assistant. If he does not he should be removed. If he does he should have his salary increased in a degree commensurate with the value of his services. This Bureau has not been able to increase the salaries of the assistants in a degree commensurate with their services, and therefore we have lost to other better endowed surveys men who have been trained in our service.

It is only possible to keep such well trained men as are interested, to such a degree, in scientific investigations, that the more remunerative employment with large mining companies does not

serve as an unbalancing attraction. Geological surveys are suffering today from the necessity of employing men who have insufficient training, owing to the fact that there is a greater demand for trained geologists, on the part of the mining companies, than he market will supply. During the last two years even the United States Geological Survey has lost some of its best trained economic geologists as a result of this demand.

During the last year there have been three men constantly employed on the staff of this Bureau. The correspondence, examination of specimens and supervision of the chemical and drafting work requires the presence of at least one person in the office all the time. However, there have been weeks during the year when there was no one in the office except the clerk.

As a rule the Director has given his personal attention to all correspondence except that pertaining to the special investigations in charge of the assistants. Mr. Buehler supervises all chemical work, checking the results and outlining the mehtods to be employed. Mr. Crane has in charge the work in the drafting room, which includes the preparation of illustrations for the various reports.

## PUBLICATIONS.

Since the publication of the last biennial report we have published two special volumes and have five others in manuscript form, which will be published during the next year. The volumes that have been published are "The Geology of Moniteau County," and "The Geology of the Granby Area." The first is one of a series of county reports begun four years ago. The second is an economic report containing a discussion of the lead and zinc deposits of an area in Newton county. Both of these reports have been eagerly sought by parties interested in mining. Men interested in mining in the lead and zinc fields of Southwestern Missouri have been especially interested in the report on "The Granby Area," which in its discussion of the origin of the lead and zinc ores furnishes suggestions which should be helpful to all prospectors.

The reports which are in manuscript form are as follows: "The Geology of Morgan County," "The Lime and Cement Resources," "Materials for and Methods of Highway Construction," "The Geology of the St. Francois County Lead District," and "General Geology of Missouri."

The report on "The Geology of Morgan County" was promised for publication two years ago. Professor C. F. Marbut, the

author, has been delayed in the completion of this report by duties connected with the University. The management of this Bureau is in no way responsible for the delay. The finished manuscript is in our hands, corrected up to date, and it probably has not suffered any from the lateness of its completion.

The report on "The Lime and Cement Resources," by Mr. H. A. Buehler, is also in manuscript form. The preparation of this report has required a great deal of field work and Mr. Buehler has visited ever county in which it was thought that materials suitable for the manufacture of Portland cement might exist. Specimens have been collected and analyzed, outcrops have been examined, and economic conditions studied so that we may be able to answer intelligently any inquiries that may be made as to the suitability of certain localities for the manufacture of cement.

The results of these investigations seem to indicate that Missouri contains, in a number of undeveloped places, limestone and shale well adapted to the manufacture of Portland cement. At least, this report will indicate areas which warrant further detailed exploration.

There are now two Portland cement factories in operation and two more in process of construction in this State. Were all the areas, where suitable limestone and shale for the manufacture of Portland cement occur, provided with adequate transportation facilities, this State might supply the entire Mississippi Valley with cement. With the transportation facilitles whch we now have, we predict an enormous expansion of the Portland cement manufacturing industry in the near future.

This State is abundantly supplied with limestone, suitable for the manufacture of quicklime. However, for many uses, the lime is being supplanted with cement, which leads to the belief that there will be, in the country at large, less activity in the quicklime business in the near future. The introduction of processes of hydration and the use of quicklime as a fertilizer may stimulate the industry to such an extent as to more than offset the use of cement.

The price of Portland cement is, at present, very high, when one considers the cost of manufacturing, which should not exceed eighty cents per barrel.

The report on "The Material for and Methods of Highway Construction," by the Director of the Bureau, has been prepared during the last six months at the direction of the Board of Managers. In collecting the information bearing upon the condition of the roads I have had the co-operation of the rural free delivery

carriers through the direction of the United States Postoffice Department. Photographs have been secured showing the character of the improved and unimproved highways; and drawings are being made illustrating the latest methods of improving the highways. Each of the different kinds of pavement in use in the cities is discussed and full specifications for construction are given. Sidewalk, curb and gutter constructions are also considered in this manner.

The chapter on "Materials Available" brings out the necessity for a State testing laboratory, where comparative tests of stone, cement, brick and pipe may be made without cost to the town or village submitting the materials for examination.

The chapter on "Methods of Construction" brings out the need for carefully executed topographic maps, such as are being prepared by the U. S. Geological Survey. The preparation of maps showing the hills, valleys, streams, buildings, roads, marshes, etc., should precede the systematic, permanent improvement of highways by the State.

The report on "The Geology of the St. Francois County Disseminated Lead District," by the Director, has been in preparation for some time and would have been published before now had it not been for the additional reports which he has been called upon to prepare. The field work for this report has been finished, the maps are being engraved and the manuscript will soon be ready for the publishers.

The report covers the geology of one of the most important lead-producing districts in the United States. The origin of the lead has been very obscure and few persons have been able to offer any tangable reason for the position of the ore bodies. The study of the physical conditions existing in this district has been an extremely slow and sometimes tedious process. Close application and persistent work, however, have furnished us with data which it is thought give the basis for a reasonable hypothesis of the origin of the ores. Such being the case, an application of the theory ought to assist very greatly those who are engaged in prospecting for new or exploiting old ore bodies.

These investigations have resulted in limiting the area of profitable prospecting for bodies of disseminated ore, on at least three sides, and by pointing out the structural and other conditions within the mineralized area, should assist very greatly in the location of new ore bodies.

The report on "The General Geology of Missouri" is intended

as a manual for those interested in geology or mining; but it is so arranged that it will serve as a useful reference book for teachers of physical geography in the public schools of Missouri.

This volume has been written in response to a wide-spread demand among prospectors and miners for a "book" containing the rudiments of geology. In this volume the common minerals and rocks are named and described, and simple methods of identifying them are given; the common structures in rocks are described and their origin considered; the geologic agents, through which changes upon the surface of the earth are brought about, are discussed; and there is a chapter devoted to the geological history of Missouri. The second part of this volume is devoted to a discussion of the mineral, stone, clay and other similar resources of Missouri. This is accompanied by maps of the State showing the location and distribution of all mines, quarries, clay-working plants, cement factories and limekilns. There are also geologic and relief maps, and maps showing the production by counties of the more important mineral resources, including lead, zinc, coal, barite, iron, stone, cement, quicklime, and clay products.

The statistics upon which the maps showing production are based are necessarily incomplete, owing to the inattention shown by some producers to our repeated requests for this information.

Of the reports published by this Bureau the following volumes remain for distribution. They are sent out to those desiring them upon receipt of the amount of postage given below:

| | |
|---|---|
| Preliminary Report on Structural and Economic Geology, Vol. XIII, 1900, by John A. Gallaher | 2,950 |
| New Year's Announcement, January 1, 1901, by John A. Gallaher | 423 |
| Biennial Report of the State Geologist to the 41st General Assembly by Leo Gallaher | 356 |
| Areal Geology, Vol. XII, Part II., by C. F. Marbut and G. C. Broadhead | 159 |
| Biennial Report of the State Geologist to the 39th General Assembly, by Charles R. Keyes | 143 |
| Geology of Miller County, Vol. I, 2nd Series, 1903, E. R. Buckley, A. F. Smith and S. H. Ball | 1,103 |
| The Quarrying Industry of Missouri, Vol. II, 2nd Series, 1904, by E. R. Buckley and H. A. Buehler | 1,971 |
| Biennial Report of the State Geologist to the 42nd General Assembly, by E. R. Buckley | 285 |
| The Geology of Moniteau County, Vol. III, 2nd Series, 1905, by F. B. Van Horn | 1,337 |
| Biennial Report of the State Geologist to the 43rd General Assembly, By E. R. Buckley | 748 |
| Geology of the Granby Area, Vol. IV, 2nd Series, 1906, by E. R. Buckley and H. A. Buehler | 2,675 |

These reports are distributed upon application, provided the request is accompanied with stamps to cover cost of mailing, as follows:

Vol. XIII, 25c.; Vol. XII, Pt. 2, 25c.; Vol. I, 2nd Series, 25c.; Vol. II, 2nd Series, 40c.; Vol. III, 2nd Series, 15c.; Vol. IV, 2nd Series, 20c.; all others, 10c.

## TOPOGRAPHIC MAPS.

This State has never made an appropriation for topographic mapping in co-operation with the United States Geological Survey, although neighboring states are yearly taking advantage of the co-operative plan to secure maps which are of inestimable value to all who are interested in internal improvements, such as highways, drainage, irrigation, etc. In spite of this apparent lack of interest, we have succeeded, through the friendly relations existing between the United State Geological Survey and this Bureau, in securing the preparation of one or more topographic sheets each year.

The making of topographic maps should always precede a study of the geology, and in having the Forsythe sheet, comprising parts of Ozark and Taney counties, mapped, we have planned to study the geology of that area. During the last two years sheets comprising an area of 1500 square miles have been mapped topographically.

## EQUIPMENT.

The equipment of the Bureau may be said to consist of a library of about four thousand volumes of reports and pamphlets; six thousand specimens of minerals, ores, rocks and fossils; and miscellaneous instruments required for field work.

*The library* consists almost exclusively of reports of home and foreign geological surveys; transactions and proceedings of scientific societies; technical journals; and reports of departments or bureaus of mines and mining. These volumes have cost nothing except the transportation charges on our own reports which have been sent in exchange. By means of exchanges we have been gradually adding to the library such reports as we believe will be valuable for reference in prosecuting the investigations being carried on by this Bureau. There are many volumes on geology and mining published each year, but for the purchase of which we have never devoted any of our appropriation. Sometime, in order to make the library what it should be, these volumes should be purchased. There are in the library several hundred volumes of transactions of scientific societies and technical journals which should be bound, but for which funds have not been available.

*The Specimens* which are in the museum have not been collected with a view to their exhibition qualities, but chiefly to illustrate the usual characteristics of the rocks, ores and minerals

of the State. The collection of lead and zinc ores is being added to each year and with some attention it will soon be among the most valuable in the country. During the past two years over two hundred spcimens have been added to this collection. Additions have also been made to the collections of rocks, fossils, barite ores, clays, etc. Owing to a lack of exhibit cases a considerable portion of this collection is packed in boxes. There is in this collection the nucleus of what might be made a magnificent representation of the mineral, clay and stone resources of the State.

The *equipment of the Bureau* includes chiefly compasses, levels, transit, aneroid barometers, tape lines, hammers, balances, drafting instruments, office furniture, filing cabinets, typewriter, etc.

Most of the equipment, including the furniture, has been in the Bureau for years and should be replaced by new. The most efficient service can only be rendered by those who have at their command the best tools with which to work.

The Bureau does not have the necessary machinery, instruments or furnaces for testing stone, clay and other materials which may be valuable for cement, brick, tile, etc. There is no machinery for testing cement, tile, brick and other materials used in the construction of buildings, highways, etc. These will be considered in another chapter in which the needs of the Bureau are discussed.

# CHAPTER II.

## A REVIEW OF THE WORK OF THE BUREAU FOR 1905 AND 1906.

The work of the Bureau may be separated into two general classes: (1) That which is conducted for the purpose of publishing special areal, county or general reports, and (2) office and laboratory investigations to supply to individuals information relative to the mineral resources of the State.

The work of this Bureau can best be summarized in the following paragraphs taken from our report to the "Forty-third General Assembly":

1st. To ascertain the relations existing between the different rock formations at or near the surface of the earth and prepare county reports containing maps, drawings and other illustrations setting forth these facts and giving the thickness, surface distribution, structure and characteristics of each formation.

2nd. To examine the metallic and non-metallic mineral resources, including stone, clay, cement, road materials, soils, water, lead, zinc, iron, coal, petroleum, asphalt, copper, barite, sand, etc., publishing complete reports outlining their distribution and describing their manner of occurrence.

3rd. To collect, name and arrange a collection of specimens illustrating the geology and mineral resources of the State; also to assist the colleges and schools in the making of similar collections.

4th. To examine ores, rocks, soils, clays, and other mineral specimens for citizens of the State, reporting as to the kind and value of any specimen submitted for examination.

5th. To disseminate, everywhere, correct ideas as to the occurrence, origin, and relation of ores, minerals and rocks, for the purpose of increasing the general intelligence of the public on matters pertaining to geology and mining.

6th. To answer all inquiries relative to the mineral resources of the State.

7th. To examine, upon petition of fifty freeholders, lands upon which ores, clays, stone or other mineral resources of value may be thought to exist.

8th. To co-operate with the United State Geological Survey and other bureaus of the United States Government where benefit will accrue to the State.

The ultimate purpose of this work is to aid in the the development of the mineral resources (metallic and non-metallic)—1st, by preparing maps, charts and reports, which will assist the prospector in carrying on his work with greater accuracy and a higher degree of intelligence; 2nd, by calling the attention of the public to undeveloped and partly developed resources; 3rd, by examining and reporting on specimens submitted by citizens of the State to this department; 4th, by increasing the general intelligence of the public through sending out to colleges and public schools mineralogical collections and published reports and addressing mining clubs and other organizations; 5th, by answering inquiries relating to the mineral resources of the State.

Under the first of these duties it may be said that we have practically established the succession of formations in the Ozark region, through field work in the southeastern and southwestern portions of the State. To accomplish this the formations have been mapped over special areas and sections have been made across various portions of the country for which geological maps have not been made. The structures along the lines of these sections have been observed and their effect on the changes in the surface geology have been determined. These results will be embodied in maps and drawings to be inserted in the forthcoming report on the "General Geology of Missouri." An attempt has also been made to correct the boundary lines between the various formations, so that subsequent editions of the geological map may delineate them more accurately.

The second of the duties enumerated above has consumed a large part of the time of myself and assistants. For several years we have had under investigation the disseminated lead district of St. Francois county. The problems connected with the occurrence of the ore bodies of that district have been extremely difficult to solve. The operators have been prospecting the region with little or no idea of the relations which the ore bodies sustain to the structure and stratigraphy. They have had very vague ideas as to the probable limits of the productive area.

We believe that the origin of these ores has been determined; that the relations between the ore bodies and the structures have been worked out; and that the limits of the productive area have been fairly well established on three sides. The determination

of these facts should be of great value to the State by directing prospecting into those areas which offer some hope of containing bodies of disseminated ore.

Our investigations in the southwestern lead and zinc district, which are, in part, contained in the report on "The Geology of the Granby Area," brought out facts, bearing on the relation of the ore bodies to the country rock, which should be very helpful to the prospector. Although our investigations in that district have not determined the probable limits of the producing area, we are confident that there is an extensive territory in this part of the State which should receive the attention of those interested in mining.

The report on the Granby area gives a full discussion of the origin of the lead and zinc minerals and the relations of the various structural features and formations to the ore bodies. The forthcoming report on the General Geology of Missouri will contain maps showing the area underlain by the ore-bearing formation and the location of the mines now in operation. Our investigations begun in the Granby Area should be continued over the entire district in order to fully supply the information most helpful to the prospector.

The constantly increasing demand for Portland cement in this country has led to an active demand for information concerning the location of limestone and shale deposits suitable for the manufacture of this material. For more than a year we have been carrying on an investigation of the limestone and shale deposits in all parts of the State. The results of this investigation, when published, will show that there is an abundant opportunity for the manufacture of Portland cement in a great number of localities, especially in the northern and eastern parts of the State. In conducting this investigation, we have examined deposits of shale and limestone in the field and made determinations of their probable extent. Observations have also been made relative to the probable cost of exploitation and the nearness of the locality to an adequate supply of fuel. Analyses have been made of the limestones and shales and from these we have been able, in a measure, to determine the fitness of the materials for the manufacture of Portland cement. Chemical analyses are, of course, not final, it being extremely important that actual burning tests be made. The Bureau, however, is not equipped with the necessary facilities for these experiments. Although the results of our investigations are not final, they are sufficient to indicate localities which offer promise of successful exploitation to those who desire to manufacture Portland cement.

In connection with the investigation of the Portland cement resources, we have made an examination of the limestones to determine their suitability for the manufacture of quicklime. Although it is true that quicklime is, in a measure, being supplanted by cement, nevertheless, it will be many years before the demand for quicklime will be materially decreased. Through these investigations we are able to state that there are numerous undeveloped localities possessing limestone suitable for the production of quicklime.

It is evident from our investigations that the railroads, through discrimination in rates, control the location of lime plants along their lines. The large producers apparently have an advantage over the smaller ones. However, in the face of this it has been extremely difficult during the last months of 1906, for even the large plants to secure cars to move their product and thus fill the orders already booked.

The demand for information on materials for highway construction has led us to investigate the character of the materials available for highway improvement in Missouri. These investigations have not included tests of stone, but have been confined chiefly to an examination of the highways and the materials in close proximity which might be used for their improvement. We have also conducted an investigation of the condition of the highways throughout the State. The results of all of these investigations will be published in a volume on Highway Construction, to which the reader is referred.

Although we have not taken up the systematic investigation of any of the other mineral resources of this State, we have been called upon to make reports upon lands thought to contain valuable deposits of coal, iron, petroleum, barite, etc. It appears quite essential that this Department should take up an investigation of the petroleum and gas resources in the northwestern part of this State and the barite in the southeastern part.

The third duty with which this Bureau is charged has been constantly in our mind. We have been collecting, naming and arranging specimens, illustrating the geology and mineral resources of this State whenever opportunity presented itself. It has not been possible to collect the specimens in sufficient abundance to distribute to colleges and schools in the State. We have had very little, if any call, for mineral collections, but it is known that the teachers in our public schools are desirous of securing such spec-

imens as may be available. This Bureau would perform a very valuable educational service to the children in Missouri, if this Bureau could be provided with funds for the making of collections to be used in the schools and colleges of the State.

The fourth duty with which this Bureau is charged has been fully carried out. We have received many specimens of ores, rocks, clays and minerals from citizens of this State, all of which have been examined and reported upon by this Bureau. In some cases, where it was thought that the conditions warranted, chemical analyses have been made. In most cases, however, the specimens were merely identified and their value reported upon. The examination of specimens consumes considerable time, requiring a part of the time of one of the assistants throughout the year.

The fifth duty with which the Bureau is charged, we believe, has been faithfully performed. Whenever an opportunity has presented itself, we have sought to explain the origin, manner of occurrence and relation of ores, minerals and rocks to those interested. In some instances we have addressed commercial clubs and other public organizations relative to the geology and mineral resources of their immediate locality. Geology and mining appear to be two of the branches in which the public has had little or no instruction. For this reason some difficulty is met in explaining intelligently the conditions which may be favorable or unfavorable to the occurrence of minerals or ores in any special locality.

The sixth duty, which calls upon the department to answer inquiries relative to mineral resources in the State, has been promptly performed. We receive inquiries concerning the varied resources of Missouri from citizens in different parts of the United States. Some inquiries also come to us from foreign countries. A majority of our correspondence is with citizens of Missouri.

The examination of lands upon which ores, clays, stone or other mineral resources of value are thought to exist, upon petition of fifty freeholders, has been fully carried out. All petitions of this character have been answered. The reports, which are made in conformity with this statute, are published in the following chapter.

This Bureau has co-operated constantly with the United States Geological Survey and with other Bureaus of the United States Government. In co-operation with the United States Geological Survey, we have secured the mapping topographically of several areas within the state. Several of the geologists of the United States Survey have spent weeks in the state assisting

in working out some of the more difficult geological problems with which this Bureau has been confronted. We have been assisted in every possible manner by the United States Government in carrying on our work. In most states, there is a definite plan of co-operation, but in this State we have been unable to enter into a co-operative arrangement on account of a lack of a specific appropriation for this purpose.

# CHAPTER III.

## REPORTS SUBMITTED IN ANSWER TO PETITIONS.

In 1901 the Legislature passed a law directing the State Geologist to examine and report upon lands in any county in this State, upon presentation of a petition signed by not less than fifty freeholders residing in the neighborhood of said lands, which may be thought to contain valuable ore or upon which they have found valuable "ore, clays, rocks, coals, minerals, oils or mineral matter," said petition to be certified to by the clerk of the county court in which the petitioners reside.

Since the passage of this law no specific appropriation has been made to carry out its provisions. Occasional petitions have been received, and each has been answered in person, either by the State Geologist or his assistant, the expenses being met out of the general appropriation for the Bureau.

The law does not require that the results of the examinations be published in the biennial report, but rather in the final reports. It is believed, however, that the interests of the citizens are better conserved by publishing the results of these investigations in the biennial reports.

The following are copies of the reports made during the last two years, in answer to petitions:

### REPORT ON QUARRY NEAR ROCHEPORT.

Mr. C. H. Carter, Liberal, Mo.:

Dear Sir—On June 29, 1905, I made an examination of the stone outcropping in the N. ½ of Sec. 17, T. 48, N., R. 14 W., for the purpose of determining its suitability for the development of a quarry to furnish stone for buildings and other constructions. Accompanying this report is a section showing the succession of beds with a brief description of each.

| | |
|---|---|
| 12-15 ft. | Beds not opened. Apparently rather thinly bedded, although they will probably become solid when worked into the hill. Flint nodules probably occur, although their presence could not be detected owing to soil. Color and texture similar to lower portion of section. |
| 6 in. | White Flint. |

| | |
|---|---|
| 5 ft. | Gray, coarsely crystalline limestone in beds from 6 to 18 inches thick. Large suture joint 2 ½ feet from bottom. |
| 6 in. | White Flint. |
| 5 ft. 6 in. | Coarsely crystalline, bluish gray limestone. Very fossiliferous. Flint noted 3 feet from bottom, probably a layer at this point. Suture joints from 6 to 12 inches apart. |
| 6 in. | White Flint Nodules. |
| 2 ft. | Fossiliferous, coarsely crystalline, gray limestone. |
| 6 in. | White Flint. |
| 3 ft. | Medium to coarsely crystalline limestone showing occassional flint nodules 1 foot from base. Suture joints. |
| 1 ft. 8 in. | Layers of flint and gray limestone. |
| 2 ft. 9. in. | Coarsely Crystalline, homogenous bed of gray limestone. Suture joints occur from 4 to 6 inches apart. |
| 1 ft. | Round nodules of flint |
| 1 ft. 4 in. | Coarsely textured, gray limestone. |
| 3 ft. | Thin beds of limestone from 4 to 6 inches in thickness with interbedded layers of white flint. |
| 1 ft. 6 in. | Gray, fossiliferous limestone. |
| 6 in. | White Flint. |
| 12 ft. | Gray to brown, fossiliferous limestone. Changes somewhat in texture being very crystalline and very fossiliferous. Free from flint except 4 feet from top where one or two nodules were noted. Suture joints from ½ to 2 inches in thickness occur from 2 to 10 inches apart. Ledge will work solid. |
| 6 in. | White Flint. |
| 3 ft. | Coarsely crystalline, very fossiliferous limestone. Shows large 3 inch suture joint in center of bed. |
| 10-12 ft. | Slope. |

This section shows a variable (1-15 ft.) thickness of lœss (clay) overlying the stone. Underneath this lœss there are 12 to 15 feet of limestone, which was so poorly exposed that I was unable to determine the quantity of flint which it contains. In texture and color it does not vary materially from that underneath. From this bed to the base of the hill beds of limestone alternate with layers of flint nodules, as shown in the section. Near the top there are two beds of limestone, 5 feet and 5 feet 6 inches in thickness, separated by layers of flint nodules, which could be quarried economically. They are medium textured and have a grayish color.

Seventeen feet of the section below these beds consists of alternating thin beds of limestone and flint nodules. Unless these beds can be utilized in crushing and in lime kiln plants it will not be practicable to work the quarry to a greater depth. If these seventeen feet can be disposed of in such a manner as to pay the expense of removal, a 12-foot ledge, which lies underneath, will furnish a good grade of building stone.

In general, there are three ledges of stone which will furnish mill blocks for building purposes. These may be channelled. The remainder of the quarry contains stone which will be waste unless used for burning quicklime or crushed for ballast and concrete work.

It is my belief that a quarry can only be operated at this place, with profit, in conjunction with quicklime and crusher plants to dispose of waste. This would necessitate a considerable investment.

The success of lime and crusher plants will depend upon fuel, transportation and markets, each of which must be investigated before opening up a plant. These I have not looked up.

The stone belongs to the Burlington formation, and is similar to that quarried near Hannibal. It is a very pure limestone, and should make a first-class quicklime.

Respectfully submitted,

H. A. BUEHLER.

## REPORT ON PETITION FROM RICH HILL.

Mr. John Klumpp, President Rich Hill Oil and Gas Development Co., Rich Hill, Mo.:

Dear Sir—On July 11, in response to a request of the Board of Directors, I made an examination of the lands under option by the Rich Hill Oil and Gas Development Co., for the purpose of making recommendations relative to a continuation of the drilling now in progress.

During the investigation, three questions arose:

1st. The identity and depth of the Mississippian limestone.

2nd. The probability of finding petroleum or gas below the Mississippian limestone.

3rd. The probability of finding petroleum or gas above the Mississippian limestone.

First—The evidence at hand leads me to believe that the Mississippian limestone occurs at a depth from 250 to 450 feet, depending upon the altitude of the surface of the land, the distance and direction from Rich Hill, and iregularities in the contact surface of the Mississippian limestone with the coal measure strata.

Second—The holes which have been drilled in the western part of Missouri, from Newton county to Livingston county, give no evidence that either petroleum or gas occur within or below the Mississippian limestone. For this reason I cannot recommend drilling through this formation.

Third—Drill holes in the western part of Missouri show that oil and gas occur in the sandstone, and even in the shale (slate) above the Mississippian limestone. Our records, however, indicate that the gas pressure is light, and that the oil is of an asphaltic na-

ture. The conditions for a large supply of gas may exist in the formation above the Mississippian limestone, but up to the present time they have not been discovered. Wherever the sandstone is sufficiently thick and extensive to constitute a storage reservoir, its proximity to the surface admits of the escape of the gas along the lines of outcrop and through fissures. As a result, the quantity of petroleum and gas are usually very limited.

There is evidence of an unusually large body of sandstone crossing the farm of Mr. C. C. McGinnis. It occurs under conditions which are more favorable for the retention of oil and gas than any with which I am acquainted in your immediate vicinity. It is possible that this sandstone may contain a considerable quantity of gas. The present drilling, however, shows a very light pressure, and for this reason the presumption would be against the occurrence of gas in commercial quantity. I am inclined to believe, in spite of this, that there is sufficient encouragement to warrant the company in drilling several additional holes to a depth of not to exceed 350 feet. These holes should be located northwest of where the drill is now stationed. If these holes are barren, I would recommend the abandonment of the project.

Recpectfully submitted,

E. R. BUCKLEY,
State Geologist.

## REPORT OF PETITION FROM AVA.

Mr. M. C. Reynolds et al., Ava, Mo.:

Gentlemen—In answer to your petition received July 12, I visited Ava, August 1st, and examined the W. ½ of Sec. 11, T. 26, R. 16, in order to ascertain the probable occurrence of oil and gas upon said section.

The above land occupies an east and west valley just north of Ava, the hills rising gradually on either side. The surface formation consists of dolomitic limestone of Cambro-Ordovician age, covered with residual clay and chert fragments. Nodules and thin layers of iron oxide occur in the clay. Beneath the limestone occurs a sandstone bed which outcrops between Ava and Mansfield, and is said to be exposed along the stream some distance west of Ava. No shale bodies were noted in the region.

What was thought to be an indication of oil consists of a thin irridescent scum covering small stagnant pools, which generally show a reddish sediment of oxide of iron. This scum is due to a

thin film of oxidized iron, brought into the pool, in solution, by seepage. The iron gradually settles to the bottom, causing the red precipitate, which colors the surface of the clay.

Gas occurs in the creek bed northwest of the city, and in a spring some distance up stream. At both places small bubbles of gas rise to the surface of the water at irregular intervals. The gas, occurring in the stream bed is combustible, and has been noted only during the past year. A short distance up stream is a saw mill, which has been in operation for three or four years, and from which sawdust and refuse is dumped into the stream. A portion of this refuse, washed down stream, has undoubtedly lodged in the gravel and clay covering the creek bottom. To the decomposition of this material, which generates combustible gases, is due the gas in the creek bed.

An examination was made of the gas in the spring, and it was found to be non-combustible and odorless. It is undoubtedly air drawn along with the water issuing from the spring.

No geological structures favorable to the storage of oil and gas were noted in the district. The only formation having sufficient openings for the retention of any considerable amount of these materials is the sandstone occurring below the dolomitic limestone. Further there is no impervious layer above this stratum to retain oil and gas were it ever present in the sand. The streams have also cut into it in many places, forming openings along which both oil and gas would escape. This sandstone, which was examined between Ava and Mansfield, shows no indications of having ever been impregnated by oil. The formations are geologically much older than any in which oil and gas have been found.

From the above considerations I do not believe that either oil or gas occur in commercial quantities in the vicinity of Ava.

Respectfully submitted,

H. A. BUEHLER,

Assistant State Geologist.

## REPORT ON AN EXAMINATION OF A TRACT OF LAND NORTHEAST OF PARIS, INCLUDING SEC. 36, T. 55, R. 10 W., SEC. 1, T. 54 R. 10 W. PART OF SEC. 6, T. 54, R. 9 W., AND PART OF SEC. 31, T. 55, R. 9 W.

On the 7th of October, in company with Messrs. Frank W. McAllister and J. W. Fouche, I made an examination of the above-described lands. This examination consisted in traversing, on foot,

the principal valleys and ravines, inspecting all the outcrops visible at the surface; and in going into the coal mine in section 1 and studying carefully its position with respect to the formations as observed at the surface.

The limestones belonging to the Mississippian era are below the horizon at which one may expect to find coal. In fact, one who is familiar with the relation which this formation bears to the coal measures, would not expect to even prospect this limestone, either by sinking shafts or drilling into it.

If one is to understand the peculiarities of the manner of occurrence of the coal measures and the coal, he must know the conditions under which they were laid down. These may be easily understood when we picture a land surface in many respects similar to the one we now have. It was not level, but, trenched with streams, and it consisted of hills and valleys.

The Pennsylvanian sea, in which the coal measures strata were deposited, filled the valleys *first*, and often in these depressions, especially near their heads, there accumulated vast quantities of vegitable matter. This was subsequently transformed into coal, forming locally a very thick seam. The presence of these valleys or local depressions are often indicated by the presence of cannel coal. It seems that these depressions were necessary for its formation.

It is in one of these ancient valley deposits that the mine in Sec. 1 is located. The seam in this mine has a thickness of about 6'-8', of which 5½' is bituminous and 3' (not exposed) is cannel coal.

The base of the coal measures at this mine is about 620 feet above sea level, while the prairie land north and west is 720 feet above sea level—a hundred feet higher. As nearly as could be determined, the top of the Mississippian limestone is at an average elevation of 660 feet. This would make the thickness of the Coal Measure strata and overlying soil about 60 feet. Locally in the ancient valleys, as pointed out above, the Coal Measures may be 100 feet thick.

The conclusions reached from the examination may be briefly summarized as follows:

1st. That the seams of coal encountered at a depth below 660 feet above sea level, will not be co-extensive with the prairie land, since they occupy valley-like depressions in the underlying Mississippian limestone. This applies to the seam being exploited in Sec. 1.

2nd. That above an elevation of 660 feet A. T. a seam or seams of coal may occur. These seams are undoubtedly very much thinner than the seams which occur in the depressions referred to above. They will, however, be persistent over a much greater area, underlying probably the entire prairie. Their thickness can only be ascertained by drilling or sinking shafts down to the Mississippian limestone.

3rd. In some places this seam may be removed, as a result of glaciation. This is a factor that we cannot figure on.

4th. The coal, occurring in the depressions, is probably not as desirable as that which may be found by drilling on the prairie.

5th. The pockets of coal occurring in the depressions may be sufficiently large to work, and may afford thousands of tons of coal. It is estimated that a seam of coal five feet thick will produce over six thousand tons of coal to the acre. The area underlain by these pockets can only be determined by sinking shafts or drilling.

6th. I would recommend drilling a number of holes to determine the area of the thick seams and also a number of holes on the prairie to ascertain the thickness and character of the coal which may occur underneath the more elevated tracts of land.

Holes might be drilled to advantage in the N. E. ¼ of Sec. 36, T. 55, R. 10 W.; in the S. W.¼ of Sec. 1, T. 54, R. 10 W.; and near the middle of the N. W. ¼ of Sec. 36, T. 55, R. 10 W. These holes will probably not need to be over 100 feet deep.

7th. The coal which was examined, on account of its proximity to the surface, was weathered and broken into small pieces with seams. It also contains iron pyrites finely disseminated through it. The quality will probably improve as the seam is worked deeper into the hill.

Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

## REPORT ON PETITION FROM GOODMAN.

Mr. D. A. Burch, Goodman, Mo.:

Dear Sir—In response to a petition from yourself and other property holders of McDonald county, I visited and examined certain lands described in said petition, situated along Buffalo creek, and described as follows:

N. E. ¼ S. W. ¼ Sec. 12, T. 23, R. 34 W.; N. E.-N. W. Sec. 13,

T. 23, R. 34; S. E. N. W. and N. E. S. W. Sec. 14, T. 23, R. 34; N. W. S. W. Sec. 26, T. 23, R. 34; S. E.-N. W. Sec. 26, T. 23, R. 34; N. E. S. W. Sec. 27, T. 23, R. 34; N. W. S. E. Sec. 27, T. 23, R. 34; N. E. S. E. Sec. 27, T. 23, R. 34.

I found this section of the county to be underlain chiefly with the Mississippian limestone, which, in certain places, is covered with a varying thickness of shale and sandstone belonging to the Pennsylvanian. The valleys are covered with soil, clay and gravel and everywhere on the ridges and hillsides there is broken flint. On some slopes the flint is more abundant than on others.

On the following described properties I examined the broken rock taken from shafts sunk thereon:

1. N. E. ¼ S. W. ¼ Sec. 13, T. 23, R. 34W.—Shaft 116 ft. deep.
2. N. E. ¼ S. W. ¼ Sec. 14, T. 23, R. 34W.—Shaft 25 to 30 feet deep.
3. N. W. ¼ S. W. ¼ Sec. 26, T. 23, R. 34W.—Shaft 60 feet deep.
4. S. E. ¼ N. W. ¼ Sec. 26, T. 23, R. 34W.—Shaft 16-20 feet deep.
5. N. E. ¼ S. E. ¼ Sec. 27, Shaft 220 feet deep.
6. N. E. ¼ S. W. ¼ Sec. 27, T. 23, R. 34W.—Shaft 25 feet deep.

Shaft No. 1 is almost entirely in Pennsylvanian shale. On the hillside above and on that across the ravine the Mississippian limestone outcrops. Some limestone boulders were encountered near the base. Pyrite is quite abundant in the shale, and where it is exposed at the surface the shale is yellow as a result of the oxidation of the pyrite. Where fresh the shale is blue. With the shale there occurs a thin seam of coal, pitching at a high angle. The limestone outcropping at this place contains no very thick beds of flint.

Shaft No. 2 passed through some shale but chiefly limestone. There is limestone on the hillsides above and below. Some pyrite in the shale.

Shaft No. 3 passed through some shale but is chiefly in limestone. This shaft is near Buffalo creek and limestone occurs on the hillside to the east and above the shale. Some blende was reported from this shaft.

Shaft No. 4 is mainly in limestone. There is nothing to note except perhaps the small percentage of flint and the freshness of the limestone.

Shaft No. 5 is the deepest of any in the area examined. It passed through limestone although on the hillside, northwest of the shaft, there is considerable shale. In the road below the shale outcrop, a thin, knife-blade seam filled with galena was observed. The shaft passed through some limestone carrying zinc blende in cavities. The samples on the dump were not rich enough to indi-

cate a rich ore body, but gave evidence that the underground waters must have carried zinc in solution and that wherever open flint ground occurs there is a probability of finding an ore body.

Shaft No. 6, is shallow but the rock on the dump carries some blende. On the knoll just north there is some sandstone which in places near the base is conglomeritic. A thin veinlet of galena was observed in one of the blocks broken from the surface. There are several other shallow shafts on this land.

In addition to the shafts several holes have been drilled in this area. The cuttings from one of these holes was examined. It consists chiefly of limestone, which indicates that the flint is subordinate in quantity. It is reported that blende was encountered in several of the holes, but the cuttings from these holes were not seen.

In general it is my impression that this limestone, where examined, is too tight in most places to permit the accumulation of zinc blende in quantities sufficient to make ore bodies of commercial size and richness. It appears probable, however, that areas may be discovered where the rock is sufficiently open to admit of the necessary concentration. Prospecting close to the sandstone and shale outcrops, but not through them, is advised. It is also believed that there is a greater probability of locating ore bodies on the table land areas away from the valley, provided the shale outcrops are to be found. Prospecting should be carried on away from the shale areas in the direction in which they dip.

The conditions through which the bodies of lead and zinc ore are formed have been present over this region, but it still remains to be demonstrated, by drilling, whether or not the openings, in which the ore may concentrate, are present.

There is no commercial quantity of coal to be found in the area inspected.

Likewise there is no evidence to warrant one in predicting the discovery of oil or gas. These will probably never be found in this section of Missouri.

Some of the clay near the surface might, if washed, be used as a paint pigment.

There is an abundance of good limestone for building purposes and for the manufacture of quicklime.

Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

# CHAPTER IV.

## FUTURE WORK AND NEEDS OF THE BUREAU.

*Field Work.* With the appropriation which has heretofore been available, it has been impossible to carry on the geological investigations desired by citizens in different sections of the state. We can only carry three or four lines of investigation at any one time. If we were to undertake more it would require an undesirably long time to get the reports into print. For this reason we have delayed field work in the northwestern part of the state, where considerable interest is centered around the possibility of securing petroleum or gas. For the same reason detailed investigations of the Ozark-Taney county and other areas have been deferred. With the present appropriation we cannot complete work in any one area before urgent requests for similar work come in from other areas. It is impossible for our Bureau to anywhere near meet the demands made upon it by the mining interests of different sections of the state, in the preparation of detailed geological reports.

During the next biennial period, in addition to the investigations already under way, we wish to begin the preparation first,—of a report on "The Geology of Northwestern Missouri," with special reference to the possible occurrence of petroleum and gas; and second,—of a report covering the "Lead and Zinc Deposits of Southern Missouri," including such areas as may lie outside of the well-known "Joplin" and "Disseminated" districts. The field work for these investigations during the next biennial period will cost at least $15,000, two-thirds of which should be spent in the investigations in northwestern Missouri.

*Laboratories.* In the preparation of nearly all the reports of this Bureau, there are required chemical analyses of rocks, ores, minerals, clays, etc. In addition to this, the Bureau frequently receives specimens, from citizens, which require an analysis before an intelligent report can be made as to their value. During the summer months, when the School of Mines is not in session, the courtesy of their laboratory has been extended to our chemist.

During the time that the School of Mines is in session the facilities at our disposal are not adequate. In order to expedite the work of the Bureau along this line, we should be provided with a well-equipped chemical laboratory.

There is also need for a well-equipped physical laboratory, where tests of stone, quicklime, cement, brick, terra cotta, sewer pipe, etc., may be made; and in which there are kilns suitable for testing materials which may be thought to be of value for the manufacture of pottery, terra cotta, brick, sewer pipe, cement, quicklime, etc. Such a laboratory should also contain machinery for testing materials to be used in the improvement of the public highways. Brick, stone, asphalt, cement and, in fact, all materials of this nature, have variable qualities, which can only be measured quantitatively by subjecting such materials to tests in the laboratory.

Requests for tests of this character now come to this Bureau, but until a laboratory with necessary equipment is provided, they cannot be made. This is the age of cement, brick, terra cotta and stone, and the testing of these products and the materials for their manufacture should be carried on systematically by some department of the state government.

There should be provided for the purpose of equipping chemical and physical laboratories, the sum of $6,000.

*Topographic Maps.* The geologic mapping in the state might be reduced one-half by first preparing topographic maps. Topographic maps are not only of assistance in geological work, but they are valuable in planning highway improvements, laying out drainage districts, conducting soil surveys, and in many other ways. These maps indicate, by contour lines, the hills and valleys; they locate accurately all streams and wagon roads; and, in fact, contain all the information desired for practical, educational, political, administrative, statistical and economic purposes.

The following summary shows the uses of topographic maps:

1. "*Educational.*—(a) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

2. *Practical.*—As preliminary maps for planning engineering projects. Highways, electric roads, railroads, aqueducts and sewerage plants may be laid out on them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs and routes of canals may be ascertained from these maps.

3. *Political.*—In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

4. *Administrative and Military.*—In all questions relating to Federal or State administrations of public works, as canals, reservations, parks, highways and as military base maps on which to plan works of offense, defense, camps, marches, etc.

5. *Statistical.*—As base maps for the graphic representation of all facts relating to population, industries, products or other statistical information.

6. *Economic.*—As a means for showing the location, extent and accessibility of lands, waters, forests and valuable minerals. In this respect these maps are indispensable to State and Federal bureaus, and to owners, investors and corporations."

"In addition, as an incident in the making of a topographic map, monuments are established throughout the State, the positions of which are accurately determined by geodetic methods and which serve as datum points for all other Government, private and cadastral surveys. There are also established throughout the State bench marks or permanent monuments which furnish datum elevations for the future determinations of height in connection with all public or private engineering works. Meridian marks are established at each county seat, which aid local and county surveyors in determining the declination of their compasses and which thus greatly facilitate the search for old property lines."

"The maps that result from these co-operative surveys show, in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief, or surface forms, printed in brown, including the shapes of hills, valleys and ravines, their elevations and depressions, and the slopes of every rise or fall in its surface of the land."

"The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating States have the benefit of this publication without further expense, and the residents of the State, as well as its officials, may purchase the

maps at rates of 5 cents per sheet, or $2 per hundred." (Extract from a report of the Director of the U. S. Geological Survey.)

The United States Geological Survey has made topographic maps of several areas in Missouri during the last biennial period. One of these areas covers portions of Stone, Taney and Christian counties and the other portions of Macon, Shelby and Knox counties. These maps have been made to assist this Bureau in carrying on its geological investigations.

In a number of states the geological surveys have a co-operative arrangement with the United States Survey by which each bears one-half of the expense of making these maps. The United States Survey will make the same arrangement in Missouri, should a specific appropriation for co-operation be made. For example, if Missouri should appropriate $10,000 a year for co-operation with the U. S. Geological Survey, there would be spent in the making of topographic maps, in this state, the sum of $20,000 a year.

As an illustration of what is being done by other states in the way of co-operation, your attention is called to the following table, showing amounts appropriated biennially for co-operative topographic mapping:

| | |
|---|---|
| Ohio | $50,000 |
| New York | 40,000 |
| Oklahoma | 20,000 |
| California | 20,000 |
| Connecticut | 17,000 |
| Kentucky | 20,000 |
| Maryland | 10,000 |
| Massachusetts | 20,000 |
| New Jersey | 14,000 |
| N. Carolina | 8,000 |
| Pennsylvania | 30,000 |
| West Virginia | 30,000 |

There are now seventeen states co-operating with the United States Geological Survey in making topographic maps.

The United States Geological Survey have expert topographers in their employ, while were the state to undertake the preparation of these maps, without assistance from the Federal government, she would be obliged to develop a corps of topographers, requiring several years to reach the efficiency of those in the employ of the United States.

It is our earnest recommendation that there be appropriated for topographic maps in co-operation with the United States Geological Survey the sum of at least twenty thousand dollars ($20,000).

*Publications.* It is the intention to continue the preparation of county geological reports. In addition, we expect to publish re-

ports on special mineral resources covering the entire state. We may also take up the preparation of reports dealing with the physical geography of the state, to be used in the public schools.

In the way of economic reports, there should be prepared those covering "Petroleum and Gas," "Coal," "Barite," "Asphalt and Asphaltic Rocks" and "Lead and Zinc." We have issued a volume on "The Quarrying Industry" and have volumes on "The Lime and Cement Resources," and on "Materials for Highway Improvements" in preparation.

*Recommendations.* To carry on the work of this Bureau with the greatest possible efficiency the by-laws governing the Bureau should be amended in several particulars. These amendments should be such as to accomplish the following objects:

1st. The Board of Managers should be made non-partisan, by designating that not more than two of the Board should represent any one political party. Their terms of office should expire successively, one each year.

2nd. A new section should be added, making it lawful for the State Geologist, or any of his duly authorized assistants, to enter, examine or inspect any and all mines or lands in the state of Missouri at all reasonable times.

3rd. The Bureau of Geology and Mines should also be charged with the compilation of statistics showing the amount and value of the output of all mines, quarries, clay-working plants, lime kilns, cement factories and such other mineral stone or clay products as may be exploited in the state.

4th. A new section should be added authorizing the establishment of chemical and physical laboratories for examining ores, rocks, clays, minerals, water, brick, terra cotta, sewer pipe, cement, concrete, asphalt and any other materials that may be used in the construction of buildings or the improvement of the public highways.

5th. A new section should be added as follows:

"The Board of Managers may, during any biennial period, expend a sum, not to exceed one-half of the general appropriation for the maintenance of the Bureau, in the preparation of county reports, including geologic or topographic maps, or both. The Board is further authorized to enter into an agreement with the County Court of any county in Missouri to make such reports, provided one-half the cost of preparing and publishing said reports shall

be guaranteed to be paid by said county either from the treasury of said county or from private subscription."

*Estimate of Appropriation.* To carry out the provisions of the law creating the Bureau of Geology and Mines, as outlined in Chapter 110, of the Revised States of Missouri for 1899, and the amendments thereto, passed by the 41st General Assembly, the Board of Managers consider it necessary that the following appropriation be made:

| | |
|---|---|
| For maintenance and support, including salaries and expenses of State Geologist, assistants and clerks | $31,500 |
| For equipment for chemical and physical laboratories | 6,000 |
| For topographical mapping in connection with the U. S. Geological Survey | 20,000 |
| For printing, engraving, and preparing maps and other illustrations | 7,000 |
| Total | 64,500 |

# CHAPTER V.

## OBSERVATIONS ON MINING DEVELOPMENTS IN MISSOURI DURING 1905-'06.

Missouri ranks eleventh in the value of her mineral resources, being surpassed by Pennsylvania, Ohio, Michigan, West Virginia, Colorado, Illinois, Montana, Indiana, California and Minnesota. The value of the mining products for 1905 was approximately thirty-seven and a half millions of dollars distributed as follows:

| | |
|---|---|
| *Zinc | $9,091,943 |
| *Lead | 7,403,730 |
| *Coal | 7,147,665 |
| Barite | 111,811 |
| Clay Products | 5,639,318 |
| Building Stone, Quicklime, etc. | 3,756,722 |
| Iron Ore | 330,000 |
| Petroleum and Natural Gas (estimated) | 12,390 |
| Cement (Portland) estimated | 4,000,000 |
| **Silver | 12,900 |
| Total | $37,506,479 |

From the above statement it appears that zinc still maintains the lead in the value of the mineral resources. Lead is second and coal third. There has been an increase in the value of all the products of the mines and quarries, the output as a whole surpassing that of any former year.

*Asbestos.* There are two fibrous minerals commonly known as asbestos. One is chrysotile and the other actinolite. The first named variety does not, to our knowledge, occur in Missouri, at least in deposits of commercial size. The second occurs in at least two localities, one in Iron county and the other in Crawford county.

The fibre of asbestos from these localities is long but brittle. The exposed portion of the veins are small and it is somewhat doubtful if they can ever be exploited economically.

*Asphalt and Asphaltic Rock.* The deposits of bituminous sandstone and limestone in the western part of the state remain undeveloped. The cheapness of the asphalt obtained from the distillation of petroleum in the western and southern oil fields

*From the report of the Bureau of Mines and Mine Inspection.
**From the report of the Director of the Mint.

has probably been a large factor in retarding the exploitation of the asphaltic rock of Missouri.

There are extensive deposits of asphaltic sandstone and limestone in the western part of the state, which might be used for paving. More detailed information regarding these deposits can be obtained by referring to the biennial report to the 43rd General Assembly.

*Barite.* This mineral, which is known variously as barytes, "ball tiff," "tiff," "heavy spar" and "spar" occurs associated with galena in many places over the Ozark region. It is one of the most stable compounds known and often occurs in a practically unaltered condition embedded in clay close to the surface. It also occurs in caves and fissures in the dolomite, sometimes in large, beautiful crystals.

The barite mined in Missouri occurs chiefly in the Potosi formation (dolomite), although there are deposits in younger formations of the Ozark region.

The chief producing areas are in Washington, Jefferson, St. Francois and Franklin counties. Barite has also been obtained from Miller, Morgan, Cole, Camden and Hickory counties. Texas, Crawford, Phelps and other counties also contain deposits of this mineral, most of which are undeveloped.

There are three factories in this state using barite, two in St. Louis and one in Mineral Point. Those in St. Louis are the "Nulsen, Klein and Krausse Mfg. Co." and "The J. C. Fink Mineral Milling Co." The one in Mineral Point is "The Point Mining and Milling Company."

The exploitation of this resource is being carried on in about the same manner that it has been for the past five years. The Southeast Missouri Barytes Company is the only company operating on a large scale. This company uses traction engines to haul the product from the mines to the station, and has otherwise sought to improve the methods of exploitation.

There are many deposits of barite in the Ozark region which have never been mined, on account of their distance from the railroad. These will sometime be valuable, and records should be kept of their location.

The total value of all barite mined in the United States in 1905 was $148,803. In contrast to this we note that the value of barite products imported into the United States during the same period was over $300,000. There should be some way by which

the barite producers of the United States might be enabled to supply this market now occupied by the European manufacturers.

*Building Stone.* The most important quarries in this state are located in the neighborhood of Carthage. The pure white limestone belonging to the Burlington formation is here known as the Carthage limestone. The quarries have been very active during the last two years and two new companies have come into the field, "The Carthage Superior Limestone Company," and The Missouri Stone and Construction Co. The uses for the stone are being multiplied, and everywhere there are evidences of increased activity.

The development of the granite quarries remains unchanged. The operators have not changed since the publication of the report on "The Quarrying Industry." The value of the output has changed very little.

One of the surprising things about the Granite quarrying industry is the slowness with which it develops. In several counties in southeastern Missouri there are extensive areas of granite, well adapted to all kinds of building constructions as well as monumental work. However, there is comparatively little interest in this resource and correspondingly slow development. For information on the granite quarrying industry, with map showing the distribution of the igneous rocks, reference should be made to Vol. II, 2nd Series of the reports of this Bureau.

At Hicks Station, "The Ste. Genevieve Stone and Construction Company" has opened a new quarry near the right-of-way of the St. Louis and San Francisco railroad. The quarry is in the Aux Vasse sandstone and is equipped with steam channeler, gang saws and other necessary machinery for operating on a large scale. This quarry is very favorably situated and the stone is of good quality for building purposes. It has a pleasing buff color. Mr. H. Ward Hicks of Ste. Genevieve is manager.

There have been some additional developments at the Regenhardt quarry at Cape Girardeau. The quarry has reached a depth of nearly one hundred feet. At a depth of ninety-five feet a ledge was encountered which takes a very excellent polish, having much the appearance of the Tennessee marble. The stone is solid and can be obtained in large dimensions.

The condition of the quarries at Hannibal, Warrensburg, Breckenridge and other places has changed very little since the publication of the report on "The Quarrying Industry."

The Hughes Stone Company has absorbed all the quarrying interests at Noel and Madge, and are now operating on a much larger scale.

Crushing plants have been installed at a number of places, notably at Princeton and Gilman.

*Chat.* The tailings from the concentrating plants of the lead and zinc districts are known as chat. In the Southwestern Missouri district they are chiefly flint, with some limestone. In the Southeastern Missouri district they are dolomite. The flint chat is sharper and much harder than the dolomite, and will therefore wear better in places where it is subject to abrasion. It is better when used in the construction of granolithic or granitoid pavements on account of its hardness, and it is preferable for street paving, because it will wear longer and proves to be less dusty and muddy. However, in concrete constructions, such as walls, basements, or foundations to pavements, the dolomite chat is equally as desirable as the flint. For railroad ballast there is practically no choice between the two. Neither is as well adapted to this use as rock crushed to a size of 1½ to 2 inches. It is much cheaper and has been used very extensively by all railroads entering the mining districts.

In the Flat River district chat can be purchased at the mines for about $2.00 a car, where it is to be used in the improvement of the public highways. In the Joplin district chat is sold at about 12½ cents per cubic yard or $3.75 to $4.50 per car to the railroads, and could probably be purchased at the same figure for paving. This provides a very inexpensive material, which is at all times accessible to the public for highway improvements.

It is thought that the chat of these districts constitutes a very important asset to the resources of the state. It should be used more extensively for the improvement of the public highways, and some arrangement should be made by which the railroads will haul it to distant points at a much less cost than at present. The rates which are now charged are almost prohibitive. Besides its use for highways, it might be used for the manufacture of artificial stone, electrical conduits, sewer pipes, etc.

VALUE OF PRODUCTION OF STONE QUARRIES BY COUNTIES IN 1905.

| County. | Value of output. | County. | Value of output. |
|---|---|---|---|
| Adair | No returns. | Lawrence | 27,200 00 |
| Andrew | $21,120 74 | Marion | 110,070 00 |
| Atchison | 200 00 | Mercer | 64,644 55 |
| Barry | 208 50 | Miller | 10 00 |
| Barton | 380 00 | Moniteau | 500 00 |
| Bates | 5,842 50 | Monroe | 1,225 00 |
| Benton | 800 00 | Montgomery | 2,375 00 |
| Bollinger | 1,142 50 | Lewis | 2,225 50 |
| Boone | 1,865 00 | Lincoln | 86,873 77 |
| Buchanan | 7,786 80 | Linn | 1,185 00 |
| Caldwell | 42,970 80 | Livingston | 85 00 |
| Callaway | 650 00 | McDonald | 10,750 00 |
| Cape Girardeau | 117,340 50 | Newton | 700 00 |
| Carroll | 20,540 00 | Nodaway | 410 00 |
| Cass | 880 00 | Osage | 152 50 |
| Cedar | 800 00 | Pettis | 5,201 50 |
| Chariton | 416 00 | Phelps | 155 00 |
| Christian | 7,150 00 | Pike | 6,957 79 |
| Clark | 769 00 | Platte | 1,467 25 |
| Clay | 53,400 00 | Polk | 2,250 00 |
| Clinton | 2,135 00 | Ralls | 1,100 00 |
| Cole | 11,843 50 | Ray | 650 00 |
| Cooper | 2,000 00 | St. Charles | 14,848 60 |
| Dade | 75 00 | St. Clair | 12,775 00 |
| Daviess | 1,095 00 | St. Francois | 133,541 58 |
| DeKalb | 429 75 | Ste. Genevieve | 51,905 20 |
| Franklin | 57,024 90 | St. Louis | 1,282,855 27 |
| Gentry | 50 00 | Saline | 274 50 |
| Greene | 291,095 00 | Shelby | 122 50 |
| Grundy | 2,587 00 | Sullivan | 3,650 00 |
| Harrison | 100,100 00 | Vernon | 4,000 00 |
| Henry | 137,081 25 | Warren | 500 00 |
| Holt | 141 80 | Webster | 200 00 |
| Howell | 250 00 | Worth | 400 00 |
| Iron | 81,871 85 | Wright | 150 00 |
| Jackson | 341,335 00 | | |
| Jasper | 295,995 46 | Total | $3,355,909 92 |
| Jefferson | 51 00 | Ballast used by railroads (incomplete) | 400,813 00 |
| Johnson | 15,081 56 | | |
| Knox | 350 00 | | |
| Lafayette | 1,500 00 | Total | $3,756,722 92 |

The above table is necessarily incomplete, and does not include the production of sand, for which our statistics are too incomplete for publication.

*Clay Products.* Clay has very little intrinsic value, and no market value unless it is very pure, as in the case of kaolin and flint fire clay, such as may be used in pottery and fire brick factories. Unless very near a large city, lands containing clay suitable for the manufacture of brick, are of very little greater value than similar agricultural lands. The value of the land may be influenced by the proximity of a supply of suitable, cheap fuel, either wood, coal or gas.

To be of value in the manufacture of clay wares a deposit of clay must, first, be near to transportation facilities,—competitive transportation facilities; 2nd, there must be an abundant market; 3rd, there must be a cheap, yet suitable, fuel supply. The success of the business then depends chiefly upon the ability to make a marketable product.

Missouri has an abundance of most excellent clay. Many of the deposits of clay are in close proximity to railroad or other

transportation facilities. There is an abundance of cheap fuel, both coal and wood. One of the most fortunate circumstances is the occurrence of an abundance of clay and shale in close proximity to the large cities,—St. Louis, Kansas City, St. Joseph, Mexico, Hannibal,— suitable for the manufacture of nearly every kind of constructional material manufactured out of clay.

In the swamp lands of southeastern Missouri there are abundant deposits of clay suitable for the manufacture of drain tile, which is needed for draining the lands. In the northern part of the state there are abundant shale deposits, from which brick and drain tile of superior quality can be made.

Missouri has within her confines sufficient clay to supply the entire Mississippi valley with all the brick, tile and terra cotta which will be required for centuries to come. Yet, there is not an over production today. We might say that there are not enough factories to supply the demands of our own people, if we take into consideration the uses to which brick and tile would be put, provided the factories were nearer the consumers. The distance which these must often be transported by the railroads, adds so greatly to the cost that other materials are often substituted. In the improvement of highways, for example, the consumption of drain tile should be increased a hundred fold, and it would be, were this product obtainable at a less cost.

There would probably be more brick and tile factories in the state did the people know the possibilities of the clay and shale occurring in the immediate neighborhood of their towns and cities. There would be more brick and tile used were the manufacturers conversant with methods by which these products could be produced more cheaply than at present.

To bring about a wider and more economical exploitation of this resource the state should provide laboratory facilities, where citizens might have clay or shale tested to determine its suitability for the manufacture of different kinds of clay wares. Experimental work of this character is in line with the other investigations carried on by this Bureau, and it is hoped that an appropriation may be made to equip and maintain a laboratory for this purpose. Other states not only maintain clay testing laboratories, but also schools wherein their youth are taught the art and science of clay-working.

The following table gives the value of the clay products manufactured in Missouri in 1905, by counties:

VALUE OF CLAY PRODUCTS BY COUNTIES FOR 1905.

| County. | Value of product. | County. | Value of product. |
|---|---|---|---|
| Adair | $9,750 00 | Linn | $18,625 00 |
| Andrew | 1,950 00 | Livingston | 18,150 00 |
| Atchison | 7,645 00 | Macon | 6,560 00 |
| Audrain | 58,576 40 | Marion | 900 00 |
| Barton | 850 00 | Mercer | 600 00 |
| Boone | 16,000 00 | Moniteau | 4,099 00 |
| Buchanan | 205,889 08 | Monroe | 7,000 00 |
| Butler | 3,000 00 | Montgomery | 380 00 |
| Caldwell | 2,620 00 | Morgan | 18,789 00 |
| Callaway | 72,820 00 | Nodaway | 15,585 00 |
| Cape Girardeau | 67,665 00 | Perry | 3,950 00 |
| Carroll | 20,667 41 | Pettis | 600 00 |
| Cass | 3,841 82 | Pike | 8,800 00 |
| Cedar | 2,400 00 | Polk | 2,000 00 |
| Chariton | 10,507 00 | Putnam | 1,650 00 |
| Clark | 2,600 00 | Randolph | 88,233 89 |
| Cole | 16,500 00 | Ray | 5,398 55 |
| Cooper | 12,968 88 | Ripley | 1,610 00 |
| Daviess | 1,700 00 | St. Charles | 16,000 00 |
| Dunklin | 8,250 00 | St. Francois | 1,200 00 |
| Franklin | 7,675 00 | St. Louis | 3,881,804 51 |
| Gasconade | 13,565 62 | Saline | 7,315 00 |
| Gentry | 4,950 00 | Schuyler | 750 00 |
| Greene | 2,567 50 | Scotland | 15,500 00 |
| Grundy | 2,770 00 | Shelby | 1,412 00 |
| Harrison | 3,450 00 | Stoddard | 2,000 00 |
| Henry | 70,586 98 | Sullivan | 9,150 00 |
| Holt | 10,200 00 | Vernon | 22,498 60 |
| Howard | 2,400 00 | Warren | 880 29 |
| Howell | 2,880 00 | Webster | 900 00 |
| Jackson | 278,280 67 | | |
| Jasper | 7,000 00 | | $5,140,318 34 |
| Jefferson | 11,212 50 | Not included in above are: | |
| Johnson | 70,259 00 | Terra cotta (estimated) | 400,000 00 |
| Knox | 2,290 00 | Burned clay ballast | 99,000 00 |
| Laclede | 1,260 00 | | |
| Lafayette | 16,499 74 | Total | $5,639,318 34 |
| Lincoln | 4,100 00 | | |

*Coal.* The output of coal in Missouri for 1905 was valued at over seven millions of dollars, according to the report of the state mine inspector. This is an increase over former years, and indicates that the industry is in a healthful condition. The most important coal producing counties in the order of their importance are: Lafayette, Macon, Adair, Randolph, Ray, Platte, Vernon, Barton, Bates, Henry, Linn and Putnam, all producing over $100,000 worth of bituminous coal. There were 488 companies operating in the state. There has been mined since 1840, approximately 88,059,950 put. There were over 10,000 men employed in and about the mines.

The coal occurs entirely within the Pennsylvanian series and chiefly within the lower portion, known as the Des Moines. The Upper, or Missourian, contains some coal, but as far as it has been explored, the seams are thin. The Des Moines consists chiefly of sandstone and shale, while the Missourian is chiefly limestone. The limestone gradually increases in abundance from the bottom to the top of the Pennsylvanian series.

The Pennsylvanian strata underlie about 33,000 square miles of

territory, or approximately 30 per cent of the entire area of the state. There has been mined since 1840, approximately 88,059,950 short tons of coal. Considering the coal to have a specific gravity of 1.30, this amount of coal would occupy in the ground about 2,167,629,526 cubic feet of space. A seam of coal 36 inches thick, covering one square mile of ground, would occupy 83,635,200 cubic feet of space. Computed on this basis, the area which has been actually mined in this state amounts to about 26 square miles. If one includes in the area mined such pillars as may be left standing in the mines, the area is about 35 square miles. This means that only one-tenth of one per cent of the area underlain with Pennsylvanian strata in this state has been mined.

Provided one-twentieth of the entire area underlain with Pennsylvanian strata contains an aggregate thickness of 3 feet of coal, it will require at the rate of 5,000,000 short tons a year, about 750 years to exhaust the supply. If the output increases steadily in the ratio that it has in the past ten years, a much shorter time will be required, probably from 300 to 400 years.

One-twentieth of the Pennsylvanian series may not contain an average of 3 feet of coal. It would probably be much nearer correct to say that one-fortieth of the area is underlain with seams of coal averaging 1 foot in thickness; one-sixtieth with coal averaging 2 feet in thickness; and one-one-hundred and twentieth with coal averaging 3 feet in thickness. If this latter estimate should be approximately correct, we would have the following conditions:

| | | |
|---|---|---|
| 275 sq. miles coal—3 ft. seam | 934,362,000 | short tons |
| 550 sq. miles coal—2 ft. seam | 1,245,816,000 | short tons |
| 825 sq. miles coal—1 ft. seam | 934,362,000 | short tons |
| 1,650 sq. miles coal | 3,114,540,000 | short tons |
| Amount mined to date | 88,000,000 | short tons |
| Remainder | 3,026,540,000 | short tons |

Three billion short tons mined at the rate of 5,000,000 short tons a year would require—provided one-third is left in pillars or wasted—400 years. If the production should increase at the rate which it has during the last ten years, the coal deposits, —upon this estimate of the reserve,—would be exhausted in less than two hundred years; perhaps in 150 years.

We do not believe that this or the next generation will suffer for want of coal, but unless greater economy is exercised in exploiting the coal fields of this country, future generations will criti-

cise us for our wastefulness and extravagance. If individuals and corporations persist in plundering our resources, the government should step in and regulate their exploitation.

*Concrete Building Blocks.**—During the past two years there has been a rapid advance in the use of concrete building blocks in this state, and as this industry continually assumes greater importance increased attention is directed towards it.

A few years ago, there were no plants manufacturing concrete blocks in this state, but at present, small plants are operating in most of the large cities and in many of the smaller towns. The blocks are being used extensively for dwellings, factories and retaining walls, but more especially for foundations in the smaller cities.

The industry has been greatly injured in some localities by manufacturers who have paid very little attention either to the correct proportions of the ingredients to be used, or to the proper methods of manufacturing the blocks. In either case, the proportion of cement used often falls below that required for a first class product and the resultant blocks are neither impervious to water nor uniform in composition. This condition generally results either from ignorance or from an attempt to make the block at a cost at which it may be sold in competition with common brick.

Many patents relating to the method of manufacturing these blocks have been issued, and through them the quality of the block has been greatly improved. The patents have been directed chiefly towards the manufacture of a block out of which an impervious wall may be constructed.

The most important steps in the process of manufacture were the introduction of the staggered hole block and the two piece block construction. In the former, the block contains two series of openings, so placed that the web joining the front and rear faces is ⌊-⌋ shaped, making it more difficult for the moisture to penetrate the wall than in the case of a straight web. In the second method, separate blocks are made for the interior and exterior portions of the wall. These blocks are in contact only at the mortar joint. Where proper care is exercised, both methods of construction practically insure a dry wall.

The materials used in the construction of concrete blocks are Portland cement, sand, crushed stone or gravel and water. In order to insure the best results, these materials should be free

*By H. A. Buehler.

from organic matter or other impurities. The proportions of these materials used, varies with the kind of block manufactured. Where the block is homogeneous throughout, sand and cement are used in the proportions of four of sand to one of cement. This proportion is almost universally used in this state. Where a less amount of sand is used, the block is of inferior quality.

In blocks, known as faced blocks, which are not made homogeneous throughout, the exposed surface is generally made out of a mixture of two parts of sand to one part of cement, while the body of the block consists of a mixture of four parts of gravel (or crushed stone) and sand to one part of cement. A surface made with the above proportion of sand and cement is almost impervious, while the use of gravel or crushed stone in the body of the block, cheapens its construction without materially lessening its strength. Care must be taken to insure a perfect bond between the face and body of the block.

Chat or mine tailings, which are extensively used in granitoid work, and which occur in almost inexhaustible quantities in southeast and southwest Missouri, constitute a valuable material for use in the manufacture of these blocks. For this reason it is thought that this industry will become important in the mining areas.

The following estimated cost of manufacturing these blocks per square foot of surface is computed from returns received from forty manufacturers in this state, and are for (1) homogeneous, (2) faced blocks.

| | I | II |
|---|---|---|
| Sand | 3.6c. | 2.1c. |
| Cement | 7.3c. | 3.1c. |
| Gravel | | 2.25c. |
| Labor | 4.7c. | 4.7c. |
| Total | 15.6c. | 14.15c. |

The estimated cost of laying these blocks in the wall, averages five cents per square foot. The total cost per square foot, according to the above estimate, of the finished block in the wall is 20c.

A detailed discussion of this subject will be found in a report to be issued this winter on "The Lime and Cement Resources of Missouri."

*Copper.* The only development in the production of copper in this state is the erection of a smelter by the North American Lead Company. This company has opened up in its lead mines at Fredericktown what the company believes to be valuable deposits of sulphide copper ore.

The deposits in Shannon, Crawford and Ste. Genevieve counties are in essentially the same state of development as reported in my biennial report to the 43rd General Assembly.

*Fullers.* It requires a somewhat peculiar combination of fine *Earth* quartz sand and clay to make a first class fullers earth. Those qualities by which one can classify a quartzose clay as a fullers earth are best determined by making actual tests.

There are no deposits being exploited in Missouri at this time. Occasional samples are received from different parts of the state which appear to be fullers earth. A sample, from about ten miles south of Ava, has every appearance of being a first class fullers earth.

Fuller's earth is worth about $5.00 to $6.00 per short ton. The consumption in the United States, is about 40,000 short tons per year, used chiefly in the process of deodorizing, bleaching, and clarifying oils and fats.

*Gravel.* Under the head of gravel is included deposits from streams, lakes or other bodies of water, either present or ancient. The chief supply of this material is obtained by dredging from the Mississippi, Missouri, and Meramec rivers. The principal points at which dredging is done are Glasgow, Hannibal, Louisiana, Kansas City, Boonville, Bloomfield and near Fern Glenn. There are banks near Pacific, Webster Groves and other places from which gravel is also obtained.

The stream gravel is used chiefly for railroad ballast and concrete constructions, while the bank gravel is used chiefly for improving highways. The gravel at Pacific is especially well adapted for highway improvements. It consists of an intimate mixture of flint pebbles, clay and sand, which, when compacted, makes a hard, impervious surface.

The tailings, obtained from the concentrating mills, are frequently spoken of as gravel, but these are more appropriately considered under the head of "chat."

*Iron Ore.* All the iron ore produced in Missouri in 1905 was consumed by "The St. Louis Blast Furnace Company," of Carondelet, and "The Sligo Furnace Company," of Sligo. The total production of the state in 1905 amounted to 109,398 tons, valued at approximately $330,000.

The ore used by "The Sligo Furnace Company" was obtained from the Cherry Valley mine, at Cherry Valley, the Steelville Mine, at Steelville, and the Craig Mine at Goltra. These mines are all located near Sligo. The ore used by "The St. Louis Blast Furnace

Company" was chiefly purchased from mines located at Mudville, Leslie, DeCamp, Iron Mountain, Grandin, Salem, Kerrigan, Hendrickson, Jefferson City, Vulcan, Chaonia, Greenville, Salem, Poplar Bluff, Carson, Billings, Anderson, Republic, Palmetto, Bois D'Arc, Pomona, Birch Tree, Willard, Brookline and Emmet. The ore is both red and brown hematite.

The iron mining industry has received quite a stimulus during the last year, and many of the long neglected deposits have been opened up. Promising bodies of ore have been opened up in the vicinity of Billings and Republic; near Greenville and Williamsville; near Grandin; near Leslie; near Mudville, and near Steelville and Sligo.

It is interesting to note that some of these ore bodies are much larger than one would anticipate simply from an examination of the surface. For example, the red hematite ore at Mudville has been explored to a depth of about 100 feet. In the vicinity of Greenville, Wayne County, there are evidences at the surface of iron ore in a great many places. From a hasty examination one is led to believe that in the aggregate there may be several million tons of ore available in the area tributary to Greenville.

There is no evidence that the bodies of iron ore in this state are in any respect comparable in size with the deposits of the Lake Superior region. However, there are a great many relatively small bodies of iron ore, of excellent quality, and large enough to justify exploitation. The next few years will undoubtedly show an increased production.

Most of the ore bodies, which are now being exploited, are described in a report published by this Bureau in 1892, on "Iron Ores." The edition of this report is exhausted, but access to copies may be had in almost any of the public libraries in the state.

*Lead and Zinc.* The mining of lead and zinc in this state has been confined during the past two years to the already developed Districts in the Southeastern and Southwestern parts of the state. The producing areas in these districts have been extended and new ore bodies within the already developed areas have been opened up.

During the year 1905, there was produced 140,854 short tons of lead minerals, valued at $7,403,730; and 212,720 short tons of zinc minerals, valued at $9,091,943. The average price paid for galena in the Southwestern district was $61.61 per ton; for zinc blende concentrates, $44.55 per ton.* A very small proportion of

*From the report of the Mine Inspectors for 1905.

the galena produced by the mines of the Southeastern district is sold to smelters, it being mainly reduced to pig lead by the companies operating the mines. For this reason any valuation placed on the output must be an estimate based on current prices.

The following is a statement showing the amount and value of the output of lead and zinc minerals from each producing county in the state for 1905.*

## VALUE OF ZINC AND LEAD PRODUCTION BY COUNTIES FOR 1905.*

| County. | Value of | |
|---|---|---|
| | Zinc Ore. | Lead Ore. |
| Barry | $ 8,177 | ..... |
| Benton | ..... | $ 2,666 |
| Camden | ..... | 9,689 |
| Christian | 7,254 | 3,248 |
| Cole | ..... | 10,420 |
| Crawford | ..... | 518 |
| Dade | 8,946 | 2,628 |
| Franklin | 1,837 | 65,846 |
| Greene | 44,408 | 88,990 |
| Hickory | ..... | 11,115 |
| Jasper | 8,020,855 | 1,528,427 |
| Jefferson | 14,247 | 15,408 |
| Lawrence | 512,412 | 19,881 |
| Madison | ..... | 696,569 |
| Miller | ..... | 6,264 |
| Moniteau | 5,192 | 8,448 |
| Morgan | 961 | 2,914 |
| Newton | 468,694 | 98,540 |
| Oregon | 3,000 | ..... |
| Ozark | 975 | ..... |
| St. Francois | ..... | 4,804,719 |
| Washington | ..... | 90,446 |
| Wright | ..... | 2,109 |
| | $9,091,943 | $7,408,780 |

During the last two years the Moniteau county mines at Fortuna have been abandoned, and for that reason this county is no longer an important producer. Jasper, Newton, Lawrence, St. Francois, Madison and Washington counties show a steady output. There has been an especially noticable increase in the output of the lead mines of St. Francois county where the companies have been operating up to their fullest capacity.

The chief developments in Jasper county have been in what is known as the sheet ground. With the development of these deposits there is a tendency to conduct operations on a larger scale than has been formerly customary in the District. Larger acreage and fewer but larger mills will be the result. There are very few reasons why operations should not be conducted on a much broader

*From report of Bureau of Mines and Mine Inspection, 1905.

scale than at present. The result of such a movement would be to preserve large bodies of low grade ore which under the present system are neglected and eventually forgotten.

In Lawrence county prospecting beyond the developed area east of Aurora, carried on in a somewhat desultory manner, has shown the occurrence of other ore bodies. This Bureau has sought to encourage prospecting in this area, believing that the tributary territory offers reasonable hope for the discovery of bodies of lead and zinc ore of commercial importance.

There are also extensive areas of unprospected land in the neighborhood of Stotts City, Wentworth, Neosho, Carthage, Granby and Sarcoxie, which should command the attention of those interested in developing lead and zinc mines.

Attention should also be directed to other counties in the central and southern Ozark region, throughout which more or less prospecting has been carried on. In Phelps county two companies have been organized to prospect and develop lands situated near Newburg. Other companies are drilling lands situated near Edgar Springs. On the lands near Newburg, galena, associated with barite, has been found in a well developed flint breccia. The locality was visited during the spring of 1906, and at that time there was a sufficient showing of galena to recommend additional development work. The formation is Ordovician dolomite. It is not the same as the formation in which the Joplin ore occurs. This fact, however, in no way argues against the possibility of ore occurring in commercial quantities.

In Ozark, Taney, Stone, Oregon, Howell, Texas and other counties some prospecting has been carried on, but everything has been on a small scale. It is impossible to state at this time what the future may develop for this region. We have not had an opportunity to investigate this section of the state, and our knowledge is altogether from reports sent to the office.

Near Greenville, in Wayne county, the Holliday-Klatz Land and Lumber Company has been prospecting an unusual deposit of zinc ore. The zinc at this place is sphalerite or blende disseminated through a dike of basic igneous rock, of a greenish-gray color. The size of the deposit has not been determined, but such development as had been carried on at the time of our inspection led to the belief that it was sufficiently important to warrant further exploration. Accompanying the dike is a twelve inch vein of quartz carrying values in gold, sufficient perhaps to be developed along with the zinc ore. The determinations of the zinc and gold

values in the dike and quartz vein were not made by this Bureau, but by an assayer, whom we believe to be reliable.

Some galena has been found in the vicinity of Doniphan in Ripley county, but so little exploration has been carried on in this area that we are unable to make any statement as to the possible outcome of these developments.

In the Madison county area of the disseminated lead district considerable development work has been carried on by the Mine LaMotte Lead and Smelting Company and lessees, by the Madison Lead and Land Company and by the North American Lead Company. All these companies are in good condition from reports received at this office. In addition to the work done by these companies several others have been prospecting land under option.

In the St. Francois county area of the Southeastern disseminated lead district prospecting with the diamond drill has been carried on uninterruptedly. Eight new shafts have been or are being sunk by the companies operating in this district, while the Federal Lead Company have unwatered the two shafts of the Central Lead Company, which were flooded as the result of a strike two years ago. To take care of the additional tonnage of ore from these mines there have been erected two new mills, while a third is to be constructed next year. These three new mills, combined, will handle a tonnage of 35 to 40 thousand tons of ore a day.

The investigations which this Bureau has been conducting to determine the origin and the manner of occurrence of these ores are about completed and it is expected to publish the results in a volume to be issued this spring.

In Washington, Franklin, Jefferson, Cole and other counties prospecting has been carried on in a small way and some ore is being marketed yearly. A short time ago our attention was called to some very good specimens of zinc ore (blende in limestone) obtained from a prospect in Boone county. Thus search for these important metals is going on over the Ozark region and spreading north across the Missouri river.

*Manganese.* Manganese occurs in various forms in different localities in the state. In the lead mines of Madison county it occurs in a soft earthy form commonly known as wad. In Wayne county it occurs with brown hematite, constituting a manganese iron ore. The extent of these deposits has not been determined. Samples of manganese from the S. E. ¼ Sec. 20, T. 33, R. 28W. and Sec. 5, T. 39, R. 3W., have also been examined.

Manganese occurs quite widely distributed over the southern

part of the state but nowhere is it known to occur in deposits of sufficient size to be considered workable. The value of manganese varies from $5.00 to $15.00 per short ton.

*Mineral Paints.* The principal paint pigments produced in this state are lead, zinc and barite. Some kaolin, pulverized limestone and soft red hematite, of an argillaceous nature, are exploited for this purpose. Very ferruginous clay has been mined and sold from this state, being classed as umber and sienna. The amount produced is not known.

The Picher Lead Company is now placing on the market in addition to their well known sublimed lead, a natural blue lead, having a steel blue color. The company claims that this pigment possesses durability, elasticity, toughness, smoothness, and color not possessed by other lead pigments. It is especially recommended for coating iron and steel.

*Mineral Waters.* In 1904 there were eighteen springs reporting sales of mineral water. The quantity sold was 333,204 gallons, valued at $53,741.* According to the above, Missouri ranks eighteenth among the states in the production of mineral water. The total number of mineral springs recorded by the U. S. Geological Survey as occurring in Missouri is twenty-six. This is of course only a fraction of the number actually existing in this state.

In 1892 this Bureau published a report on Mineral Waters, since which time no attempt has been made to further investigate this resource. The water supply of a state is one of its most important resources, and could be made, by judicious business management, a source of considerable revenue. In Illinois, for example, the sale of mineral waters amounts to over $3,000,000, annually. This Bureau is desirous of obtaining information as to the location and characters of mineral springs in this state, in order to assist in making these waters better known among our people.

*Nickel and Cobalt.* There has been a great deal of discussion relative to the occurrence of nickel and cobalt in the lead mines of Madison county. There is no question as to its occurrence in these mines, the only point being whether or not it can be recovered economically. The same class of nickel and cobalt sulphides occur in some of the mines near Flat River, especially in the abandoned mine on the land owned by the Union Lead Company. The reports from those who operated this mine and conducted the prospecting indicate that the property is underlain with irregular bodies

*From the reports of United States Geological Survey.

of nickel-cobalt sulphide ores, in the shape of lenses, usually disseminated through the limestone for a space of 20 to 30 feet.

The Mine La Motte company has for several years reported to the Mine Inspection department a large valuation in nickel and cobalt contained in old mattes from the lead furnaces. However, to our knowledge, nickel or cobalt have not thus far been refined at this place.

The Madison Lead and Land Company, owning the Catherine Mine, ship a small amount of nickel and cobalt sulphides. The North American Lead Company are erecting a refinery and expect to treat their own nickel and cobalt ores, of which they have a considerable quantity.

These sulphides occur everywhere associated with the galena, sometimes in sheets but often disseminated through the dolomite with the galena. In the latter case they can be discovered only by separation on the tables or from the matte after the lead has been smelted.

These ores all occur in Cambrian dolomite, known as the Bonne Terre formation.

*Petroleum and Natural Gas.*

There have been very few developments in the oil and gas industry in this state. During the summer of 1906 a company has been drilling at various localities in St. Louis county, and have lately announced that gas was encountered, at a depth of 1,150 feet, near Rankin station. This bureau has not investigated the report and the quantity of gas is unknown. At least two holes over a thousand feet in depth have been sunk. In our biennial report to the 43rd General Assembly we said—"There is very little probability of encountering either gas or petroleum in large amounts in the small basin of Carboniferous rocks, upon which St. Louis is located. * * * * The structure of the region, combined with the restricted nature of the basin argues against finding either petroleum or gas in large quantities." We have no reason to change this opinion expressed two years ago.

The northwestern portion of the state, in which there has been very little prospecting, is the region most liable to produce commercial quantities of gas and petroleum. In that part of the state there exist most of the conditions known to be favorable to the production and storage of petroleum and gas. The structure of the region has never been carefully worked out, although the reconnoisance maps of the early geologists, published in 1872 and 1873, show the presence of flexures which may serve as caps to

reservoirs occurring within the Des Moines (lower coal measures) strata below.

A careful geological survey of this region, showing the folding or flexuring, would be an extremely valuable aid in prospecting for these fuels.

*Onyx.* Throughout the Ozark region there are caves in the dolomite and limestone formations. Some are large, extending underground for a half a mile or more, and others are small, merely caverns. Many of these caves were formed during an ancient erosion interval—not the present. These were later filled, in whole or in part with travertine, or cave onyx, as it is called. This onyx resembles the Mexican variety and often, when polished, exhibits beautiful surfaces, having a variegated coloring. It is seldom obtainable in large blocks free from flaws, for which reason attempts to exploit these deposits have been abandoned.

All the deposits of onyx have not been examined as to their quality but there is no apparent reason why some may not yet be profitably exploited.

*Portland Cement** During the last biennial period, there has been an exceptionally active demand for Portland cement, and a corresponding activity in its manufacture. The plants at present in operation in this and adjoining states, have been unable to supply the demand and there has been considerable interest manifest in the erection of new plants, as well as increasing the capacity of those already in operation.

The Atlas Portland Cement Company now operates at Hannibal, two distinct plants known as No. 5 and No. 6, each of which have a capacity of 5,000 barrels per day. The St. Louis Portland Cement Company, located at Prospect Hill, north of St. Louis, have recently increased their capacity to 5,000 barrels per day. The plant at Louisana, upon which preliminary work was started some three years ago, has not been completed, and no further work has been done, although the raw materials are present in inexhaustible quantity.

During the past year, the Kansas City Portland Cement Company, of Kansas City, Missouri, have started the erection of a plant, located on the Missouri river bluffs, directly north of Independence, Missouri. The plant will be completed in April, 1907, and will have a capacity of 2,500 barrels per day.

The Missouri Portland Cement Company, organized by parties

*By H. A. Buehler.

in St. Joseph, Missouri, contemplate the erection of a plant at Iatan, Missouri. The raw materials occurring in the vicinity of Princeton, are being investigated at the present time, to determine their suitability for Portland cement. Should the quantity prove sufficient, it is probable that an attempt will be made to erect a small plant at that place.

This State is well supplied with the raw materials necessary for the manufacture of Portland cement. Both the Hannibal and St. Louis plants are using limestones of Mississippian age. The shales belong to the Devonian and Lower Coal Measures strata, respectively. The eastern portion of the state is underlain with inexhaustible quantities of these materials, which, together with the Trenton limestone, occurring beneath the Devonian, make this an attractive field for Portland cement factories.

While the Lower Coal Measures do not contain limestones of sufficient thickness for Portland cement manufacture, the upper Coal Measures, occurring in the northwestern porton of the state, are well suppled with both materials. The basal portion of this formation consists of strata of limestone and shale, several of which are of sufficient thickness to be used. The limestone and shale to be used by the Kansas City plant occur in this formation and are the same strata used at Iola, Kansas. This formation is also exposed at Iatan and Princeton and should plants be erected at these points, the raw materials will be furnished by strata ocuring these points, the raw materials will be furnished by strata occurring in this formation.

The two plants at present in operation in this state have a capacity of approximately 5,500,000 barrels per year. The Kansas City plant will increase this capacity by 1,000,000 barrels per year, making a total capacity for this state of approximately 6,500,000 barrels.

A full discussion of the possibilities of the Portland Cement industry in this state, with numerous analyses of shale and limestone will be found in the report on "The Lime and Cement Resources of Missouri," to be issued this spring.

*Quicklime.** The activity in all lines of building construction during the last biennial period, has created an active demand for lime. In response to this demand, a number of plants have increased their capacity by the addition of one or more kilns. Three new plants were constructed in 1905. The first of these was erected by T. W. Ballew and located two miles south of Princeton,

*By H. A. Buehler.

Missouri. It consists of three kilns. The second plant, consisting of five kilns, was erected by "The New Union Sand Company," of St. Louis, and is located just north of West Kimmswick on the St. Louis and San Francisco Railroad. This plant is modern in every respect and is modeled after the eastern plants. One kiln has been erected by "The Cliffdale Lime Company" at Brickey station on the St. Louis and San Francisco railroad in Ste. Genevieve county.

"The Hunkins, Willis Lime and Cement Company" of St. Louis, have just installed a complete electrical equipment at their plant located at Mincke station on the St. Louis and San Francisco railroad in the western part of St. Louis county. This equipment includes a 125 H. P. Weber gas engine, 75 and 35 K. W. Westinghouse generators and motors to operate the coal conveyors, blowers, compressors, pumping plant and crushing plant. This plant has undoubtedly by far the best mechanical equipment of any west of the Mississippi river. The company is also erecting a kiln to be used exclusively for experimental purposes.

"The Ash Grove White Lime Association" has just installed a Clyde hydrating plant, at Ash Grove, and are now marketing hydrated lime. Two grades of hydrate are produced, the first is made from the best quality of Ash Grove White Lime and is known as Snowflake hydrate. The second grade is produced from a yellow dolomite which has a yellowish tint when burned and hydrated. It is known as Canary hydrate. This is the first attempt to produce dolomitic lime in this state in commercial quantity.

Throughout many of the plants there has been a general improvement in the mechanical handling of both the stone and lime. Several plants have built tramways in place of hauling the stone by wagon. Natural gas, piped from the Kansas field, has been introduced as fuel and is now being used by plants located at Joplin and Carthage. This fuel has been found to be very economical.

The general demand for lime in this state is still almost exclusively for building purposes. A small amount is sold for fertilizer and one plant has installed a small grinder to reduce the lump for this purpose. The high calcium hydrated lime produced by the Ash Grove company, should prove admirable material for fertilizing purposes. Several car loads of lime from this state are shipped weekly to the northern tanneries. During the past three years, a considerable quantity of the lime produced in the vicinity of St. Louis, has been used for purifying the city water supply.

The Trenton and Burlington formations still produce the great

majority of the output of lime from this state, although the plants located at Ste. Genevieve use the Spergen Hill formaion and plants located at Princeton and Amazonia use beds belonging to the Upper Coal Measures. These formations, however, produce less than one-tenth of the entire output.

The lime burned from the Trenton formation, is dark in color and is known as black lime, while that produced from the Burlington is white in color. The lime produced during 1905 was valued at $712,950.

This industry has been injured to a considerable extent by the shortage of cars. One of the plants visited recently had fifty car loads of lime upon the cooling floors with order of shipment for the same, but were unable to deliver same on acount of their inability to obtain cars from the railroad company.

*Sand.* One of the very important resources of this state is sand. The uses are many but the major consumption is for the manufacture of glass, for mortars used in building constructions, for foundry purposes, for locomotives and for filters.

This state is abundantly supplied with sand suitable for all these uses. The St. Peters sandstone at Pacific, Klondike and Crystal City is used for the manufacture of the highest grade of plate glass, and is suitable for the manufacture of other grades. It is also used for locomotive, foundry and other purposes.

Sand for mortar and locomotive uses is obtained from the Kaw river near Kansas City, the Piney river near Newburg, the Gasconade river at Gerome, the Missouri river near St. Joseph, Boonville and Glasgow and from the Mississippi river south of St. Louis, near Hannibal, near Louisiana and elsewhere.

Sand is also obtained for locomotive and foundry purposes at Klondike, Morley, Fruitland, Fayette, Joplin, Nevada and other places.

Sand used for the various purposes mentioned above should possess various qualities. For mortars it should be sharp and clean. For locomotive use it should be sharp and fine. For foundry use it should contain an admixture of clay but be free from alkaline earths and alkalies. For plate glass it should be nearly pure silica and free from iron oxide and all other ingredients that might cause discoloration. For the manufacture of ordinary bottle glass iron oxide and other impurities causing discoloration are not necessarily harmful. Any ordinary sharp sand, which is clean, may be used for filtering purposes.

The sand supply for the large cities is obtained chiefly from

the Mississippi, Missouri and Kaw rivers and is obtained by dredging. The St. Louis supply is now handled chiefly by two concerns but since the sand is obtained from the rivers by dredging there is no reason why these companies should control the market.

*Silver.* The report of the Director of the Mint for 1905 credits Missouri with the production of $12,900 worth of silver. By inquiry it is learned that this silver is obtained chiefly from the galena mined in St. Francois county. It is known that one of the companies recovers the very small percentage of silver in the galena.

*Strontianite.* There is only one deposit of strontium ore being exploited in the United States and this is located in Texas. The market for strontium is very limited and the small amount exploited in Texas has been shipped to Germany.

The only known deposit of strontium ore in this state occurs in Iron county, near Annapolis. No attempt has been made to develop it.

The sulphate of strontium (celestite) is valued at $20.00 to $50.00 per ton. The carbonate (strontianite) is valued at about $4.00 a ton.

The chief uses are in the manufacture of fireworks, in beet sugar manufacture and in medicine.

*Trimbleite.* A ferruginous, argillaceous, arenaceous dolomite, named Trimbleite, by J. H. Morland of Kansas City, occurs at Plattsburg. The deposit is one foot, six inches in thickness and at the surface has a buff to yellowish color as a result of weathering. The fresh stone has a bluish gray color and is hard when quarried. It occurs seven feet below the Plattsburg limestone of the Upper Coal Measures (Missourian).

The stone is being pulverized and used in the manufacture of tooth powder, polishing powder and toilet soap, by "The Trimbleite Company," with offices and factory at Plattsburg.

*Tripoli.* The chief output of tripoli in this state comes from Seneca, in the western part of Newton county. Small deposits occur in Miller, Morgan and other counties, being exploited under the name of "chalk" or "silicate."

The chief deposits in Newton county occur within a radius of ten miles of Seneca, extending westward into Indian Territory. The deposits occur in the Mississippian series and are the product of local decomposition of chert or flint, probably belonging to the upper portion of the Keokuk formation. The soft porous rock

constituting the tripoli is the result of decomposition of hard chert or flint through the action of meteoric water.

The beds of tripoli have a thickness of from 2 to 20 feet and are usually covered with 3 to 6 feet of sticky red clay. The color varies from pure white to a bright pink, depending on the content of iron oxide. In some portions of the deposits the tripoli is soft and friable; in other parts it is firm. In some places it contains nodules of flint and in other places it is mottled with iron oxide.

The tripoli deposits of this area are controlled by one company, which is engaged in the manufacture of flitters, blotters, abrasive powder, etc. The output is increasing each year and with the abundant supply of raw material at hand promises to continue for many years. The value of the output in 1905 was approximately $50,000.

*zinc.* See Lead and Zinc.

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